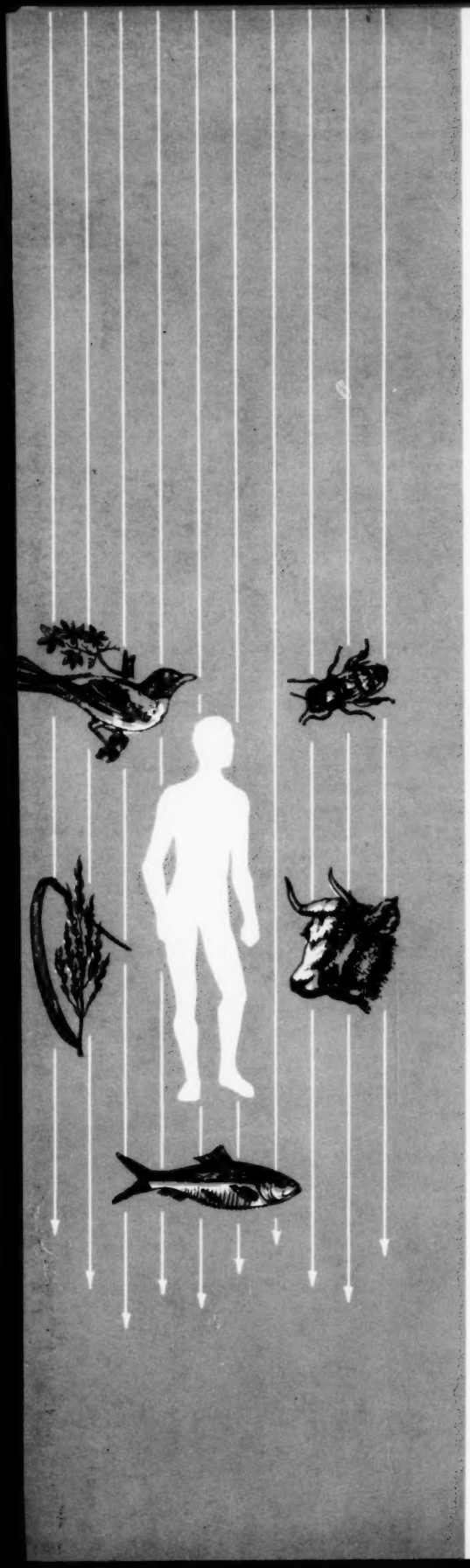

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RESIDUES IN FOOD AND FEED

A Study of the Sources of Insecticide Residues in Milk on Dairy Farms in Illinois—1971[1]

Steve Moore III, W. N. Bruce, D. E. Kuhlman, and Roscoe Randell

ABSTRACT

In 1971, a study was conducted to determine the sources of chlorinated hydrocarbon insecticide contamination to dairy cows in order to help dairy farms avoid, or recover from, a residue problem in their milk supply. Twelve dairy farms were selected from 40 herds surveyed initially in February 1971; the 12 farms had dieldrin milk residues ranging from low to medium to high. Samples of milk were collected from the 12 farms in February, March, and September; in March, samples of feed, well water, and soil were also collected. Cropping history, insecticide usage history, and cattle management practices were obtained for each farm for the preceding 10-year period, 1961-70. The following conclusions may be drawn from this study: (1) the chances of dieldrin residues in milk exceeding the Food and Drug Administration's current administrative guideline of 0.3 ppm (fat basis) are greatest on dairy farms having a history of aldrin soil treatment within the last 6 or 7 years; (2) hay and oat straw supply significant amounts of dieldrin to dairy cattle; in addition, roasted soybeans could be an important source of dieldrin contamination in milk; (3) corn silage, commercial feed concentrate, and well water are usually not important sources of dieldrin contamination to dairy cattle.

Introduction

This report is not based on controlled detailed research, but rather constitutes a gross field investigation of a problem situation having many variables. The purpose of this study, initiated in February 1971, was to determine the sources of chlorinated hydrocarbon insecticide contamination to dairy cows to help dairy farms avoid, or recover from, a residue problem in their milk supply.

During 1969-70 in Illinois, a total of 27 dairy farms were found to be producing milk with illegal amounts of chlorinated hydrocarbon insecticide residues and, in January 1971, the Illinois Department of Public Health found dieldrin residues approaching an illegal level in a sample of cheese taken from a manufacturer in northern Illinois.

As early as 1951, the Illinois Cooperative Extension Service and Illinois Natural History Survey had advised against the use of DDT on dairy farms. In 1965, they advised against the use also of aldrin, chlordane, dieldrin, endrin, heptachlor, and lindane on dairy farms and, in 1969, they recommended against the use of these compounds on all farms. The vast majority (at least 80%) of Illinois dairymen followed these recommendations and had not used these insecticides in recent years, although alternative controls and insecticides were often more expensive, less effective in controlling the insects, and more hazardous to handle.

Continued use of certain of these insecticides by a few dairymen caused the residue problem that prompted the investigation reported here, but this represented only a fraction of 1% of the total dairy farms in Illinois. Of the 27 dairy farms found to be producing milk with illegal amounts of chlorinated hydrocarbon insecticide residues, on 4 the insecticide had been accidentally fed to the cattle; on the remaining 23 the insecticide had been used intentionally but in accordance with label directions.

In September 1971, State regulations were prescribed prohibiting dairymen from applying or storing on their farms, for agricultural purposes, the chlorinated hydrocarbon insecticides mentioned above.

[1] From the Cooperative Extension Service, College of Agriculture, University of Illinois and the Illinois Natural History Survey, 280 Natural Resources Building, Urbana, Ill. 61801.

Sampling Procedures

Twelve dairy farms with dieldrin milk residues ranging from low to medium to high were selected from a total of 40 herds surveyed on February 2, 1971. The herds surveyed were Grade B dairy herds located in an intensive grain-producing area in the northwest section of Illinois; they did not represent a cross section of the State's dairy herds. The dieldrin residue in a composite milk sample from all 40 farms was 0.22 ppm (butterfat basis). In 1967, Duggan (*1*) reported that the average level of dieldrin in dairy products produced in the United States was 0.042 ppm (butterfat basis); heptachlor epoxide, 0.036 ppm; and DDT, 0.042 ppm.

Cropping history, insecticide usage history, and cattle management practices were obtained for each of the 12 farms for the preceding 10 years, 1961-70. On March 16 and 17, 1971, samples of all the feed (including concentrates and roughages), a sample of well water, a composite milk sample, and a soil sample from every field on each of the farms were obtained for insecticide analysis. The samples were collected in 1-quart screw-cap glass jars, and a piece of aluminum foil was used to cover the jar mouth before the cap was fastened. Although sampling procedures varied depending on the material, approximately 1 quart by volume of each material was obtained. Hay and oat straw samples were taken from several representative bales (from each cutting still available) with a core sampler attached to an electric drill. Corn silage was collected by running the silage unloader for about 2-3 minutes and holding the sample jar in the stream of falling silage until full. Concentrate feeds were sampled by obtaining small portions from bins or sacks at several locations. The milk sample from each farm was taken from the bulk tank after the milk was well mixed. The water sample was obtained from the well water consumed by the cattle. The soil samples were taken with a standard soil sampling probe to a depth of 6 inches using the standard method of taking samples for soil nutrient analyses.

Analytical Methods

EQUIPMENT AND REAGENTS

1. Chromatographic columns, Kontes (K-420600) Chromaflex 22 x 330 mm
2. 1-liter separatory funnels
3. Three-ball Snyder columns with 24/40 ground glass fittings
4. 250-ml Erlenmeyer flasks with 24/40 ground glass fittings
5. Aerograph Model 204 GLC with a nickel detector
6. Nanograde ether and hexane
7. 95% ethyl alcohol redistilled in glass
8. Reagent grade anhydrous sodium sulphate heated overnight at 400° C to eliminate interference
9. 50% reagent grade potassium hydroxide in water
10. Florisil heated 450° C overnight, partially deactivated by adding 5% water by weight, mixed, and stored in a glass-stoppered flask for at least 24 hours before use

EXTRACTION

Butterfat for dieldrin analysis was extracted by placing 100 ml of milk and 100 ml of ethyl alcohol in a 1-liter separatory funnel; 100 ml of ether was added to this mixture and shaken briefly, then 100 ml of hexane was added. The mixture was shaken about 200 times and allowed to stand until the phases separated. The lower aqueous phase was drained from the separatory funnel and discarded. The ether-hexane layer was then washed 3 times with 100 ml of water to remove ethyl alcohol from the nonaqueous phase. If emulsions were formed, 50% ethyl alcohol was added to break the emulsions. The ether-hexane layer was drained into a 250-ml Erlenmeyer flask, and about 10 g of sodium sulphate was added to remove water. The ether-hexane was transferred to a clean, dry 250-ml Erlenmeyer flash, A few grains of sodium sulphate were added to act as boiling chips, and the extract was placed on a steam bath, a Snyder column attached, and the solvent was removed by distillation. After cooling and solidification, 1 g of butterfat was weighed for analysis.

Ten-gram aliquots of thoroughly mixed soil samples were extracted by adding 5 ml of water, 10 ml of alcohol, and 100 ml of 50% ether in hexane. These were shaken and allowed to stand overnight before filtering into a separatory funnel. The soil residues were rinsed several times with hexane to quantitatively transfer the extract. The extracted soil was dried in an oven overnight to determine the percent moisture; 100 ml of water was added to the separatory funnel, and the mixture was shaken briefly to remove the ethyl alcohol. The ether-hexane layer was dried over 10 g of sodium sulphate in a 250-ml Erlenmeyer flask. The dried extract was transferred to a 250-ml Erlenmeyer flask. A few grains of sodium sulphate were added, a Snyder column was attached, and all but 10 ml of the solvent was removed by distillation. This extract was then ready for cleanup through a chromatographic column containing 30 g of Florisil.

Chopped hay, oat straw, corn silage, and soybean and other feeds, were extracted by the same method; 10 ml of ethyl alcohol and 100 ml of 50% ether in hexane were added to these materials in a 250-ml flask. These were gently warmed on the steam bath and allowed to stand overnight. The solvents were filtered into a separatory funnel, and the feed residues were rinsed several times with hexane to quantitatively transfer the extract; 100 ml of water was added to the organic solvents to remove ethyl alcohol. The separatory funnel was shaken briefly and the phases allowed to separate before draining off the lower aqueous phase. The extract was dried over sodium sulphate in a 250-ml flask and transferred to a 250-ml flask. A Snyder column was attached, and the solvents were removed by distillation through the column.

Five hundred milliliters of each water sample were extracted three times with 250 ml of 15% ethyl ether in hexane. Extracts were then dried over anhydrous sodium sulphate, combined in a 1000-ml Erlenmeyer flask, a Snyder column attached, and all but 2 ml of the solution removed by distillation.

The 1-g butterfat sample and the extracts from the hay, straw, corn silage, and other feed were saponified by adding 10 ml of 50% potassium hydroxide in 100 ml of ethyl alcohol. These mixtures were heated on the steam bath for 1 hour. Each saponified mixture was transferred to a 1-liter separatory funnel with 100 ml of water. The Erlenmeyer flask was then rinsed several times with hexane into the separatory funnel, and 100 ml of hexane was transferred to the separatory funnel. The mixture was shaken 200 times, and after the phases separated, the lower aqueous phase was drained and discarded. The hexane layer was washed several times with water to remove soaps and alcohol. The hexane was dried over sodium sulphate, transferred to a clean flask, and most of the solvent removed by distillation through a Snyder column. These extracts were then cleaned up through a chromatographic column containing 30 g of Florisil topped with one-half inch of sodium sulphate. The Florisil was prewet with 30 ml of hexane and a receiving glass was placed beneath the column. The hexane extract was then transferred to a column with several rinses of hexane. The aldrin and dieldrin residues were eluted from the column with 200 ml of 10% ether in hexane. After all of the solvent had passed through the column, a few grains of sodium sulphate were added, a Snyder column was attached, and most of the solvent removed by distillation on the steam bath. The butterfat eluate was made up to 50 ml with hexane for injection into the gas chromatograph. The extracts from the soil, hay, oat straw, and other feed were made up to 10 ml, and 2 to 10 μl of the extract was injected into the gas chromatograph. Recovery of dieldrin and aldrin put through this system of extraction and cleanup was found to be between 90% and 98%.

GAS-LIQUID CHROMATOGRAPHY

The operating conditions of the Aerograph Model 204 gas chromatograph were as follows:

Column:	3 mm by 2m packed with Supelcoport 100/120 mesh containing 2% QF-1 and 1.25% OV-17.
Temperatures:	Injection port 225° C Column 190° C Detector 225° C
Carrier gas:	Nitrogen at 40 ml/min

The retention time of dieldrin was approximately 9 minutes with a 25% full-scale deflection for 50 picograms. The noise level at an attenuation of 1 was less than 0.3%.

Results and Discussion

Residues of dieldrin were significant in the milk and in many of the other materials sampled on the 12 farms studied (Tables 1 and 2); trace levels of aldrin were present in some soil samples; and residues of heptachlor, heptachlor epoxide, DDT, and DDE were found only at trace levels.

Aldrin, which converts to the more stable dieldrin in soil, water, plants, and animals, has been the major soil insecticide used for corn in Illinois. During the 10-year period 1961-70, approximately 4 million acres were treated each year up to 1967 (*2*); use of aldrin has been on the decline since then, with only about 2½ million acres being treated in 1971. Six of the 12 dairymen reported using aldrin as a corn soil treatment within the 10-year period; these use records are presented below:

Farm No.	Number of years aldrin was used	Last year aldrin was applied
1	8	1968
2	5	1967
3	2	1966
4	5	1966
5	5	1968
7	4	1964

Farm No. 6 had use records only from 1966 to date but did not report using aldrin during that period.

Five of the 12 dairymen reported using a heptachlor seed treatment (an insignificant amount), and none reported using DDT during the last 10 years.

A definite correlation was found to exist between the overall dieldrin soil residue on each farm and the level of dieldrin present in the milk (Tables 1 and 2). *To convert the amount of dieldrin soil residue in parts per million to pounds per acre, the dieldrin soil residue figure given in parts per million for the top six inches of soil should be multiplied by two. The weight of one acre of typical Illinois soil 6 inches deep is approximately 2 million pounds; also, 1 lb of insecticide incorporated into this soil leaves an initial residue of 0.5 ppm.*

The several months that cattle were grazing on pasture and cropland containing dieldrin residues did not result in an increase in dieldrin residues in September milk

TABLE 1.—*Dieldrin residues in milk from 12 dairy farms in Illinois, 1971*

Dairy Farm Number	Residues in PPM for Three Sample Collections (Butterfat Basis)		
	February 2	March 17	September 24
1	[2] .5560	[2] .3360	[2] .3561
2 [1]	[2] .5294	.2740	.2773
3	[2] .4343	.2940	.1894
4 [1]	[2] .4037	.2300	.2561
5	.2786	.2800	.2757
6	[2] .3333	.2800	.2348
7	.1864	.1900	.0833
8	.1823	.2071	.0833
9	.1784	.1571	.0788
10	.1608	.1243	.0492
11	.1512	.0929	.0492
12	.1314	.1000	.0492

[1] Dry lot operation.

[2] Residues exceed the Food and Drug Administration's current administrative guideline of 0.3 ppm dieldrin in milk (fat basis).

TABLE 2.—*Dieldrin residues in feed and soils on 12 dairy farms in Illinois, 1971*
[Blank = no sample taken]

Material Sampled	Residues in PPM for 12 Dairy Farms Sampled in March 1971											
	Farm 1	Farm 2 [1]	Farm 3	Farm 4 [1]	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9	Farm 10	Farm 11	Farm 12
Hay	.0373	.0401	.0213	.0313	.0206	.0393	.0256	.0203	.0129	.0159	.0155	.0160
Hay soil [2]	.3531	.2271	.6551	.4223	.2115	.0864	.0287	.0151	<.0005	.0006	.0013	.0044
Oat straw	.0208	.0303	.0221	.0332	.0223	.0510	.0230	.0184	.0150	.0170	.0197	.0117
Oat soil [2]	.2730	.1700	.3003	.3762	.0422	.3144	.0314	.0142	<.0005	<.0005	[3]	<.0005
Corn silage	.0098	.0047	.0061				.0028		.0032	.0038	.0014	.0021
Corn soil [2]	.4507	.3590	.2583				.0095		.0008	.0006	.0027	.0013
Soybean feed [2]	[4] .0062		[5] .0133			[5] .0444	[5] .0458	[5] .0081				[4] .0064
Concentrate feed [6]	.0024	.0011	.0007	.0009	.0008	.0038	.0051	.0009	[7] .0017	.0010	<.0005	.0009
Commercial protein supplement	.0030	.0037		<.0005	.0037			.0016		.0038	<.0005	.0052
Permanent pastures												
6-inch composite core			.0251		.0173		.0009	.0046		<.0005		<.0005
Surface sample [8]			.0397		.0277		.0081	.0104		.0065		.0109
Soil average for all fields [9]	.3859	.2183	.3558	.3153	.3515	.1344	.0219	.0566	.0047	.0009	.0020	.0010

NOTE: Residues of heptachlor, heptachlor epoxide, DDT, and DDE found only at trace levels in some samples. Residues of aldrin found at trace levels in some soil samples. Each of the 12 water samples, one from each farm, had a dieldrin level of <.0005 ppm.

[1] Dry lot operation.
[2] Soil samples taken with a standard soil sampling probe to a depth of 6 inches.
[3] Purchased, no field history.
[4] Soybean meal.
[5] Roasted soybeans.
[6] Made from home-grown corn and oats plus commercial protein supplement and minerals.
[7] Commercial concentrate feed.
[8] Sampled May 25, 1971.
[9] Represents an average of residue levels in 6-inch soil samples from every field on each of the 12 farms.

samples as expected. There was a drop in the dieldrin milk residue level on most of the farms between the February 2 and March 17 samplings. Indications are that this general downward trend continued on at least 8 of the 12 farms through the spring and summer months as shown by the September 24 samples. It can be speculated that these findings are attributable to an overall decrease in dieldrin residues in crops and soils, but with a peak being reached during the winter months due to the following factors:

1. November and December are the months of heavy freshening of cattle on these farms. Dry stock and young stock could release higher than normal amounts of dieldrin in thir milk for a time after freshening.

2. Cattle subjected to extremely cold temperatures could draw on body fat reserves (dieldrin storage site) at a faster than normal rate and release greater amounts of dieldrin into their milk.

Significant amounts of dieldrin milk residues occurred even on dairy farms (Farms 8 through 12) where no aldrin was used in the 10-year period, 1961-70. Only trace levels of dieldrin existed in the soil on these farms.

The dairyman on Farm 7 had used aldrin from 1961 to 1964. Soil residues after 7 years showed just trace levels of dieldrin, and dieldrin milk residues were also low. There is some indication from the data that dairy cattle on a farm having a history of aldrin soil treatments within the last 6 to 7 years will produce milk with dieldrin residues near or above the Food and Drug Administration's current administrative guideline of 0.3 ppm dieldrin in milk (fat basis).

Decker, Bruce, and Bigger (*3*) showed that 75% of the aldrin applied to soil dissipates by the end of the first year. The remaining residue in the form of dieldrin in the soil dissipates more slowly (about 12% per year) with a half-life of 4 years.

All the samples of hay and oat straw contained significant levels of dieldrin residues (Table 2). Farms 1 through 6 had slightly higher levels of dieldrin in these materials than Farms 7 through 12. However, the dieldrin in the hay and oat straw on these latter farms could still account for a significant part of the dieldrin residue occurring in the milk.

Gannon, Link, and Decker (*4*) demonstrated that dairy cattle fed 0.05 ppm of dieldrin in their total diet produced milk with a dieldrin residue (butterfat basis) of 0.25 ppm.

Roasted soybeans being fed to cattle on Farms 6 and 7 had high dieldrin residues. Significant dieldrin residues were also present in the roasted soybeans from Farm 3, while only trace levels of dieldrin occurred in the roasted soybeans from Farm 8. The two samples of soybean meal obtained from Farms 1 and 12 showed only trace levels of dieldrin. This is to be expected since the oil (main storage site for dieldrin in soybeans) is extracted in the preparation of meal. All soybean feed had been purchased.

Corn silage, commercial feed concentrates and protein supplements, and the water on all 12 farms showed only trace amounts of dieldrin (Table 2). There was no apparent correlation between the dieldrin soil residue and the dieldrin residue in the silage. The silage was cut at heights varying from 4 to 7 inches above ground. Farms 1, 2, and 3 had the highest dieldrin soil residues, and the silage on these farms was cut at 4, 7, and 6 inches above ground, respectively. The overall dieldrin milk residue is still increased slightly by feeds with trace residues of dieldrin. In addition, cattle can absorb dieldrin directly through their skin. The amount of dieldrin absorbed by cattle lying on contaminated soil and from consuming dieldrin-contaminated soil is currently not predictable. The soil type, soil moisture level, and other factors would vary greatly the amount of dieldrin cattle obtain directly from the soil. As already pointed out, there is a fivefold increase from the level of dieldrin in the diet to the level of dieldrin occurring in the milk fat.

There was no good correlation between the dieldrin soil residues and the dieldrin residues in hay and oat straw (Table 2). Levels of dieldrin in hay and oat straw exceeded 0.01 ppm on all farms including those where no aldrin had been used for at least 10 years. The waxy coating on hay and straw can readily absorb dieldrin; therefore, it is suggested that direct contact with contaminated ground soil or blowing soil particles could account for the dieldrin residues in the hay and straw.

A higher dieldrin soil residue was present at the soil surface than in a 6-inch deep composite core sample in permanent pastures on six farms (Table 2). Aldrin had never been applied to this land, and no soil erosion from adjacent fields had occurred at the sampling sites. This would indicate that soil particles contaminated with dieldrin were transported by the wind to these fields. Cohen and Pinkerton (*5*) in a study conducted at Cincinnati, Ohio, reported the average monthly dust fall to be 15 tons per square mile. The dust source was from the southern high plains of Texas and contained 0.003 ppm dieldrin. They further stated that the movement of soil particles by air within a localized area is a certainty.

Conclusions

1. The chances of dieldrin residues in milk exceeding the FDA's current administrative guideline of 0.3 ppm (fat basis) are greatest on dairy farms having a history of aldrin soil treatment within the last 6 or 7 years. Therefore, it can be expected that additional herds, but in lessening numbers, will be found producing milk with illegal residues for about 4 to 6 more years.

2. Hay and oat straw supply significant amounts of dieldrin to dairy cattle. In addition, roasted soybeans, a relatively new feed for dairy cattle, could be an important source of dieldrin contamination in milk.

3. Corn silage, commercial feed concentrate, and well water are usually not important sources of dieldrin contamination to dairy cattle.

See Appendix for chemical names of compounds discussed in this paper.

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RESIDUES IN FISH, WILDLIFE, AND ESTUARIES

Organochlorine Residues in Estuarine Mollusks, 1965-72—National Pesticide Monitoring Program[1]

Philip A. Butler[2]

Part I. General Summary and Conclusions

Part II. Residue Data—Individual States

SECTION A: ALABAMA
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ABSTRACT

This paper describes the development of the national program for monitoring estuarine mollusks in 15 coastal States and reports the findings for the period 1965-72. The report is presented in two parts: Part I. General Summary and Conclusions, and Part II. Residue Data—Individual States.

Analyses of the 8,095 samples for 15 persistent organochlorine compounds showed that DDT residues were ubiquitous; the maximum DDT residue detected was 5.39 ppm. Dieldrin was the second most commonly detected compound with a maximum residue of 0.23 ppm. Endrin, mirex, toxaphene, and polychlorinated biphenyls were found only occasionally. Results indicate a clearly defined trend towards decreased levels of DDT residues, beginning in 1969-70. At no time were residues observed of such a magnitude as to imply damage to mollusks; however, residues were large enough to pose a threat to other elements of the biota through the processes of recycling and magnification.

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Part I. General Summary and Conclusions

Introduction

Initial investigations of the effects of pesticides on estuarine fauna were undertaken at the Gulf Breeze Laboratory in 1958 to determine if the pesticide lindane might be safely used directly in estuarine waters to control crabs preying on shellfish populations. The unexpected acute toxicity of this chemical, not only to crabs but also to nontarget organisms, revealed by these early experiments prompted a broad investigation of both the direct and indirect effects of persistent synthetic pesticides. The extent of the problem was not known, and the investigators were concerned about the potential harm to estuarine fauna exposed to drainage waters from large river basins where significant quantities of pesticides were used. Marine commercial fisheries were recognized as being especially vulnerable since a major portion of their catch, both in tonnage and dollar value, is made up of estuarine-dependent species.

The acute toxicity of a broad spectrum of pesticides was determined under laboratory conditions (*14-17*). These data, however, could be most useful only if there were information on the actual levels of organochlorines reaching the estuarine environment. Accordingly, a search was undertaken for meaningful tools to measure this type of pollution (*6*).

The decision to use mollusks as bioassay tools was based on the findings of laboratory experiments designed to measure the uptake and flushing rates of an array of organochlorine pesticides under controlled conditions. Various species of mollusks, but primarily the eastern oyster, *Crassostrea virginica*, were exposed to appropriate concentrations of pesticides added continuously to a flowing seawater system. Results indicated that oysters detect DDT in the ambient water supply at levels as low as 10 parts per trillion (10^{-11}). By the process of biomagnification, residues of DDT as high as 25 ppm accumulate in oyster tissues within 96 hours at a level of environmental contamination of only 1.0 ppb (*1*). Oysters tolerate tissue residues of DDT at least as high as 150 ppm without apparent ill effect *provided* residues are accumulated slowly. However, as little as 0.1 ppm of DDT in the oyster's water supply terminates feeding activities and at summer water temperatures (31°C) will cause death.

Organochlorine residues are flushed rapidly from molluscan tissues when the water supply is no longer contaminated. In one experimental series, for example, DDT residues of about 25 ppb in oysters and soft clams, *Mya arenaria*, diminished by 50-90% after a week of flushing in clean water. Consequently, it is possible to learn much about the periodicity of organochlorine pollution in estuaries from samples of sedentary species collected at appropriately brief intervals.

As a result of these studies, it was possible for the Bureau of Commercial Fisheries to undertake a program for monitoring pesticide residues in estuarine mollusks to determine the extent of organochlorine pollution. The collection of samples was not begun immediately in some areas, while in others, sample collection was terminated at an early date. The program was continuously operative, however, from July 1965 through June 1972. In 1971, the Gulf Breeze Laboratory and the monitoring program became a part of the U.S. Environmental Protection Agency.

The following report describes the 7-year (1965-72) data collection and discusses, specifically, the well-defined trends in the magnitude of DDT residues in estuarine mollusks. Except where noted, the term DDT includes the metabolites TDE and DDE. All residue analyses are presented, by State, in Part II of this report. A report summarizing the first 3 years of this program was published in 1969 (*3*).

Data Interpretation

Although the eastern oyster has a wide distribution, it was obvious that some other species might be more available for monitoring in different geographical areas or salinity regimes; thus, different species of mollusks were tested in the laboratory to determine their relative capabilities in the uptake and retention of organochlorine pollutants (*2*). Such information is all important for the understanding of these monitoring data.

In the tests, all species were exposed to the same hydrographic conditions with low turbidity and a salinity level about 80% that of seawater. It is probable that species accustomed to different ecological conditions would react more efficiently in nature than in the Laboratory. Caution must be exercised in the extrapolation of laboratory results to field conditions, and, at best, such data serve only as guidelines for the interpretation of residue levels in monitored samples.

In general, any of three species of oysters, four species of mussels and two species of clams were found to be reliable indicators of the magnitude of organochlorine pollution (Table 1). In some areas it was necessary to use the hard clam, *M. mercenaria*, although it is the least satisfactory of the species evaluated. Under similar

laboratory conditions, for example, hard clams accumulated pesticide residues less than half as large as those in oysters. Moreover, the residues were flushed from the clam much more quickly than from the oyster when clean water was restored.

Sample Collection and Preparation

The management of estuarine molluscan resources is the responsibility of the individual States; therefore, in each coastal area there is a cadre of specialists who are not only interested in estuarine pollution but who also have the knowledge and equipment necessary to collect shellfish samples. Without the continuing cooperation of these agencies (see Acknowledgment), this program could not have achieved its objectives.

TABLE 1.—*Pelecypod mollusks used to monitor organochlorine residues in 15 States—1965-72*

Scientific and Common Names of Molluscs	
Crassostrea gigas	Pacific oyster
Crassostrea virginica	eastern oyster
Ostrea lurida	Olympia oyster
Modiolus demissus	ribbed mussel
Modiolus modiolus	northern horse mussel
Mytilus californianus	Californian mussel
Mytilus edulis	blue mussel
Mercenaria mercenaria	hard clam
Mya arenaria	soft clam
Corbicula fluminea	Asiatic clam, fresh water

State	Species Collected
Alabama	*C. virginica*
California	*C. gigas* *O. lurida* *M. demissus* *M. californianus* *M. edulis* *C. fluminea*
Delaware	*C. virginica* *M. demissus* *M. mercenaria*
Florida	*C. virginica*
Georgia	*C. virginica*
Maine	*M. modiolus* *M. edulis* *M. arenaria*
Maryland	*C. virginica*
Mississippi	*C. virginica*
New Jersey	*C. virginica*
New York	*C. virginica* *M. demissus* *M. edulis* *M. mercenaria* *M. arenaria*
North Carolina	*C. virginica*
South Carolina	*C. virginica*
Texas	*C. virginica*
Virginia	*C. virginica*
Washington	*C. gigas*

Estuaries with well defined drainage basins and bays that could be considered "nursery areas" for estuarine fauna were selected for monitoring.

Some sites were monitored because of suspected pollution problems. To insure continuity of data, permitting detection of not only seasonal but yearly trends in pesticide pollution levels, it was essential, too, that the stations selected have shellfish populations large enough for monthly collections over a number of years. Duplicate samples of 15 or more mature mollusks were collected and prepared for shipment at about 30-day intervals. About 10% of all samples were analyzed in replicate; the remaining duplicates were discarded after satisfactory analysis of the sample. Sample collections were interrupted by the loss of shellfish populations to vandals, floods, and hurricanes, but the overall continuity of the data was good.

Coverage of coastal estuaries was incomplete in this program because other agencies were monitoring shellfish in some states, notably Alabama, Louisiana, and Massachusetts. The number of sample collections by State and year is tabulated in Table 2. The original plan was to monitor each area for 5 years so that trends in pesticide residue levels could be detected. The general absence of residues in Washington estuaries, however, prompted an earlier termination of monitoring in that State. In addition to the samples tabulated, about 2,000 miscellaneous samples of other species of vertebrates and invertebrates were collected and analyzed. These frequently had more varied pesticide residues and at higher levels than mollusks but are omitted from this report because of difficulty in determining their source.

The analysis of all samples by a single laboratory to insure uniformity seemed important in planning the program. Various potential preservatives were examined to find a method for shipping samples without resorting to refrigeration. Eventually, it was discovered that by dehydrating the homogenized tissues of mollusks or other marine animals with a desiccant mixture, the dry samples could be wrapped in aluminum foil and held without refrigeration for 15 or more days without degradation or loss of organochlorine residues (*2*). This made it possible to ship the samples by regular mail.

In practice, samples of 15 or more mature oysters or other mollusks were collected and taken to the cooperating agency's laboratory. Samples not to be processed immediately could be refrigerated for 2 or 3 days in the shell. If longer storage was necessary, animals were shucked and the undrained meats frozen in mason jars. The shucked meats were homogenized in an electric blender, and approximately 25-g aliquots were blended

with precisely three times their weight of desiccant to yield a total sample weight of about 100 g. Alternate blending and chilling (not freezing) of sample is required to achieve a dry, free-flowing product. The amount of desiccant used depends on the moisture content of the sample. Less desiccant is required for fish (two times body weight), while up to nine times as much desiccant may be used with small samples, plankton for example, to achieve a 100-g final weight of the sample to be processed. The desiccant is made up of about 90% sodium sulfate and 10% Quso (Quso G30, manufactured by Philadelphia Quartz Co., Philadelphia, Pa.), a micro fine precipitated silica.

Analytical Procedures

Throughout the monitoring program samples were routinely screened for the following substances: aldrin, chlordane, *p,p'*-DDT, *p,p'*-TDE (DDD), *p,p'*-DDE, dieldrin, endrin, heptachlor, heptachlor epoxide, lindane, methoxychlor, mirex, and toxaphene. On the few occasions when the *o,p'* isomers of DDT were detected in quantifiable amounts, they were included with the *p,p'* residues.

On receipt in the laboratory, samples were extracted for 4 hours with petroleum ether in a Soxhlet apparatus. Extracts were concentrated and transferred to 250-ml separatory funnels. The extracts were diluted to 25 ml with petroleum ether and partitioned with two, 50-ml portions of acetonitrile previously saturated with petroleum ether. The acetonitrile was evaporated just to dryness, and the residue eluted from a Florisil column (*12*). The sample was then identified and quantitated by electron capture gas chromatography. Three columns of different polarity (DC-200, QF-1, and mixed DC-200/QF-1) were used to confirm identification Operating parameters on Varian Aerograph gas chromatographs were as follows:

Columns:	Pyrex glass 6' x ⅛" (o.d.) packed with 3% DC-200, 5% QF-1, and a 1:1 ratio of 3% DC-200 and 5% QF-1, all on 80/100 mesh Gas Chrom Q
Temperatures:	Detector—210° C Injector—210° C Oven—190° C
Carrier gas:	Prepurified nitrogen at a flow rate of 40 ml/min

A few samples were analyzed by thin layer chromatography. All residues are reported on a wet-weight basis. The lower limit of quantification was 10 ppb. Laboratory tests conducted during the sampling period gave the following recovery rates: *p,p'*-DDE, 80-85%; *p,p'*-TDE, 92-95%; *p,p'*-DDT, 91-95%. Data in this report do not include a correction factor for percent recovery.

Toxaphene sometimes interfered with the quantification of DDT residues which, in these cases, are reported as approximate values. The lower limit of quantification of toxaphene was 250 ppb. The presence of polychlorinated biphenyls (PCB's) also interfered with the quantification of DDT residues. In most instances, DDT was calculated as though PCB's were not present. Acquisition

TABLE 2.—*Summary of sample collections by State and year—1965-72*

State	Principal Species Monitored	Number of Sample Collections								
		1965	1966	1967	1968	1969	1970	1971	1972	Totals
Alabama	*C. virginica*				13	20				33
California	*C. gigas*		136	180	167	139	45	75	30	772
Delaware	*M. mercenaria*		16	101	99	71				287
Florida	*C. virginica*	6	80	102	82	44	35	19	6	374
Georgia	*C. virginica*			112	127	124	121	120	60	664
Maine	*M. arenaria*	6	95	89	79	83	44			396
Maryland	*C. virginica*		18	20	26	9	15			88
Mississippi	*C. virginica*	30	71	72	72	63	66	60	36	470
New Jersey	*C. virginica*		23	44	45	39	33	27	8	219
New York	*M. mercenaria*		148	183	175	174	148	143	88	1,059
North Carolina	*C. virginica*		96	201	204	204	124	136	66	1,031
South Carolina	*C. virginica*	72	142	143	145	108				610
Texas	*C. virginica*	53	133	125	93	97	103	95	29	728
Virginia	*C. virginica*	56	117	123	120	112	105	27	9	669
Washington	*C. gigas*	40	218	223	214					695
Total		263	1,293	1,718	1,661	1,287	839	702	332	8,095

of the appropriate standards permitted the identification of Aroclor 1254® in samples from California, Florida, Georgia, Texas, and Virginia, and Aroclor 1242® in samples from Virginia. Since 1970, PCB residues have been approximately quantified in samples from Florida and, more recently, from Virginia.

There is some question as to how much interference by PCB's exists in the sample analyses reported in the early years of the monitoring program. At this time there is no way of knowing with certainty. It is considered significant that in the period 1965-70 there was a 3-8% annual increase in the domestic sale of these chemicals, and total domestic sales in 1970 were more than double sales in 1960; however, PCB residues were identified in samples from relatively few estuaries in 1971.

During the course of the program, several States extended the monitoring of their estuaries and collected more samples than the Gulf Breeze Laboratory was equipped to process. Analytical equipment similar to that used at Gulf Breeze was provided to these agencies as well as a manual of operations (Prepared by A. J. Wilson, Jr., Research Chemist, Gulf Breeze Laboratory), to insure similar methodology in analytical techniques. For the first few collections under the new arrangement, samples were split and analyses made by both the State and Federal laboratories. Excellent comparability in data was obtained (*13*) and thereafter, the State agency submitted only the monthly data reports to the Gulf Breeze Laboratory. Such arrangements were in effect during portions of the monitoring program in California, Georgia, Maine, New York, and Virginia.

Data Summaries and Discussion

DDT with its analogs was the most commonly identified pesticide and occurred in 63% of all samples analyzed (Table 3). Dieldrin was the second most commonly detected residue with an incidence of 15%. DDT and dieldrin were detected in some samples from all States monitored (Tables 4 and 5). Other organochlorine residues were encountered infrequently and generally at low levels, with the exception of toxaphene. The large number of Georgia samples containing toxaphene reflects the direct contamination of the marine environment by the effluent from a single manufacturing plant.

The incidence of DDT residues varied markedly from one drainage basin to another and was not correlated with the magnitude of the residues. Only in New Jersey and Alabama, for example, did all samples contain detectable residues of DDT, but the size of DDT residues was greater in several other States (Table 4). It is true that in both Alabama and New Jersey, monitored oyster populations were exposed primarily to the runoff from a single, although complex, drainage basin. In other States, samples were collected from several distinct drainage basins.

TABLE 3.—*Summary of organochlorine residues detected in estuarine mollusks by State—1965-72*

State	Total Number of Samples	Number of Samples with Residues >5 PPB (µg/kg) and Maximum Residue ( ) Detected in PPB (µg/kg)					
		DDT	Dieldrin	Endrin	Mirex	Toxaphene	PCB's
Alabama	33	33 (616)	6 (21)				
California	772	712 (3,970)	194 (57)	14 (19)		4 (11,000)	[1] 21
Delaware	287	216 (205)	37 (25)				
Florida	374	230 (5,390)	27 (28)				25 (390)
Georgia	664	96 (96)	141 (230)			128 (54,000)	[1] 16
Maine	396	72 (359)	14 (38)				
Maryland	88	71 (70)	11 (22)				
Mississippi	470	285 (135)	19 (20)				
New Jersey	219	219 (278)	52 (26)				[1] 6
New York	1,059	858 (596)	456 (132)				
North Carolina	1,031	768 (566)	12 (19)				
South Carolina	610	332 (154)	24 (154)		12 (540)		
Texas	728	530 (1,249)	134 (87)	22 (32)		[1] 1	[1] 5
Virginia	669	585 (678)	112 (40)				19 (2,800)
Washington	695	78 (176)	1 (120)				

[1] Present but not quantified.

TABLE 4.—*Listing of States in order of frequency and maximum value of DDT residues in mollusks*

State	Frequency of Residues (%)	State	Maximum Value in PPB
Alabama	100	Florida	5,390
New Jersey	100	California	3,970
California	92	Texas	1,249
Virginia	87	Virginia	678
New York	81	Alabama	616
Maryland	81	New York	596
Delaware	75	North Carolina	566
North Carolina	75	Maine	359
Texas	73	New Jersey	278
Florida	62	Delaware	205
Mississippi	61	Washington	176
South Carolina	54	South Carolina	154
Maine	18	Mississippi	135
Georgia	15	Georgia	96
Washington	11	Maryland	70

NOTE: These comparisons are limited in that the number of samples, number of sampling stations, periods (years) of sampling, and species of mollusks differ for each State.

TABLE 5.—*Listing of States in order of frequency and maximum value of dieldrin residues in mollusks*

State	Frequency of Residues (%)	State	Maximum Value in PPB
New York	43	Georgia	230
California	25	South Carolina	154
New Jersey	24	New York	132
Georgia	21	Washington	120
Alabama	18	Texas	87
Texas	18	California	57
Virginia	17	Virginia	40
Delaware	13	Maine	38
Maryland	13	Florida	28
Florida	7	New Jersey	26
Mississippi	4	Delaware	25
South Carolina	4	Maryland	22
Maine	4	Alabama	21
North Carolina	1	Mississippi	20
Washington	<1	North Carolina	19

NOTE: These comparisons are limited in that the number of samples, number of sampling stations, periods (years) of sampling, and species of mollusks differ for each State.

The magnitude of all DDT residues was low compared to residues reported in carnivores such as fish-eating birds. By extrapolation from laboratory experiments, the monitoring data indicate that, in most cases, estuarine pollution with DDT was intermittent and at levels in the low parts-per-trillion range. In only 38 samples (0.5%) did the residue exceed 1.0 ppm. These samples were collected in California, Florida, and Texas in drainage basins having intensive agricultural development. The single highest residue of 5.39 ppm (DDT-3.70 ppm, TDE-0.76 ppm, DDE-0.93 ppm) was observed in oysters from the Caloosahatchee River drainage basin in Florida where the seasonal pattern of residue fluctuations indicated an agricultural or at least a scheduled use of the pesticide (Fig. 1). It is significant that extensive acreage in this drainage basin was devoted to sugarcane and sweetcorn that would be maturing and receiving fairly heavy applications of pesticides during the peak residue periods indicated in Fig. 1 (R. G. Curtis, 1972, Florida Cooperative Extension Service, *personal communication*). In controlled feeding experiments in the laboratory, from 50 to 100% mortality was observed in small populations of commercial species of shrimp, crabs, and fish fed exclusively diets containing less than 3.0 ppm of *p,p'*-DDT (*4*).

In a survey of 7,000 analyses of mollusk samples completed in the period 1965-71, the mean residue composition was 24% DDT, 39% TDE, and 37% DDE. Exceptions to this average picture were Station 2 in New Jersey where DDT comprised only 4% (mean of 47 samples in 5 years) and Station 18 in Washington where DDT made up 75% of the residues (mean of 36 samples in 3 years). Biotic recycling of persistent residues is usually associated with the high percentages of DDT metabolites found in dominant carnivores. It is of interest that the metabolites were the only residues detected in many of these analyses of filter-feeding mollusks. Results of a study by Johnson *et al. (10)* indicated that there are some animals, however, such as aquatic insects, in which direct exposures to DDT result in tissue residues that are more than 80% DDE. The large percentage of the parent compound DDT in residues from Washington mollusks does imply a direct contamination of the estuarine environment, perhaps, for insect control. But in general, the percentage distribution of DDT metabolites in these samples revealed little about the kinetics of DDT in the estuary.

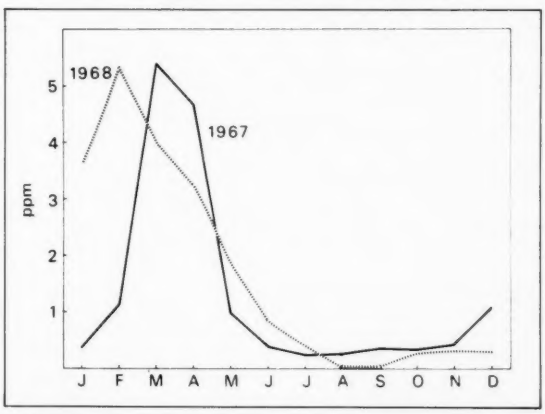

FIGURE 1.—*DDT residues in the eastern oyster from the Caloosahatchee River Basin, Lee County, Fla., by month of collection—1967 and 1968*

Trends in DDT Residues

Many of the estuaries were monitored over a sufficient period of time to permit detection of clearly defined trends in DDT residue patterns. Average DDT residue levels detected in the first 2 to 5 years and average levels in the final year of monitoring in each State are presented in Table 6. The overall picture is that of a pronounced decline, about 55%, in the number of samples containing DDT residues in excess of 100 ppb. There was a 20% decrease in the 10-100 ppb range, and a concomitant 44% increase in the number of samples having negligible or undetectable DDT residues.

There are important exceptions to this average picture. In California, New York, and Virginia, for example, more samples had residues in excess of 10 ppb in 1971 than in earlier years. On the other hand, the percent of samples having residues higher than 100 ppb declined in these States. It would appear that in some areas, DDT pollution has become more widespread, but has resulted in residues of lower magnitude in the estuarine food web.

Since organochlorine residues in mollusks showed a continuing decline in most areas during the years that domestic sales and presumably usage of PCB compounds were increasing, PCB's were not considered to be a significant factor in the early monitoring data.

Too few samples from Alabama were analyzed in this program to indicate any trend in residue magnitude. The mean value of 88 ppb of DDT in 33 samples collected in 1969-70 may be compared, however, with a mean residue level of 330 ppb in a series of 82 samples of oysters collected in 1965-66 (*7*).

Exact comparisons by States of the data in Table 6 are not valid since in succeeding years there were different numbers of samples and occasionally different species of mollusks collected at the same station. A more critical review of data on DDT residues is possible for 10 stations in North Carolina. These stations were selected for the continuity of sampling of the eastern oyster at monthly intervals for more than 5 years. The number of samples containing less than 11 ppb of DDT increased steadily until, in 1971, 76% of all residues were in this category as compared to only 8% in 1966 and 1967. The corresponding decrease in the number of samples containing larger residues is shown in Fig. 2 and Table 7.

TABLE 6.—*Percent distribution of DDT residues of different magnitude in estuarine mollusks by State—1965-71 (7,000 samples)*

State	Percent Distribution of Samples							
	<11 PPB		11-100 PPB		101-1,000 PPB		>1,000 PPB	
	First 2 to 5 Years	1971	First 2 to 5 Years	1971	First 2 to 5 Years	1971	First 2 to 5 Years	1971
Alabama			69		31			
California	14	7	30	64	51	28	5	1
Delaware	23	30	62	67	15	3		
Florida (1 station)	43	100	57					
Georgia	85	96	15	4				
Maine	82	98	17	2	1			
Maryland	19	50	81	50				
Mississippi	42	72	56	27	2	1		
New Jersey		7	69	74	31	19		
New York	26	22	60	74	14	4		
North Carolina	22	76	68	24	10			
South Carolina	52	82	47	18	1			
Texas	34	52	53	45	13	3	<1	
Virginia	18		67	95	15	5		
Washington (1 station)	92	94	8	6				
Mean	39	56	49	39	11	5	<0.5	

TABLE 7.—*Trends in magnitude of DDT residues in oysters, 10 stations, North Carolina*

Year	Total Number of Samples	<11 PPB		11-100 PPB		101-1,000 PPB	
		Number of Samples	Percent Distribution	Number of Samples	Percent Distribution	Number of Samples	Percent Distribution
1966	60	5	8	45	75	10	17
1967	119	9	8	90	76	20	16
1968	120	26	22	70	58	24	20
1969	120	29	24	77	64	14	12
1970	109	61	56	46	42	2	2
Subtotal	528	130	25	328	62	70	13
1971	115	87	76	26	22	2	2
Percent change in 1971 from average for 1966-70		+204%		−65%		−85%	

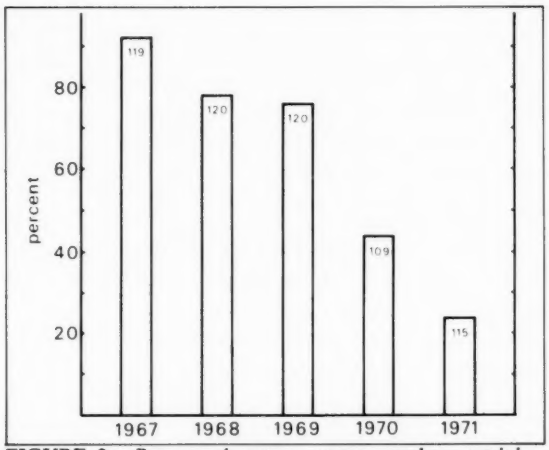

FIGURE 2.—*Percent of eastern oyster samples containing more than 10 ppb of DDT, average of monthly samples collected at 10 stations in North Carolina (Numbers in bars indicate total number of samples)*

Conclusions

The data demonstrate that in most estuaries monitored, detectable DDT residues have declined in both number and magnitude in several species of estuarine mollusks in recent years. DDT pollution in many estuaries, as judged by the magnitude of the residues in mollusks, peaked in 1968 and has been declining markedly since 1970.

The sensitivity of mollusks to organochlorine pollutants plus the fact that they are filter-feeders warrant the assumption that the contribution of particulate DDT to estuaries from one or more primary sources such as drainage basin runoff waters, atmospheric fallout, and persistent reservoirs in bottom sediments, has declined significantly.

In view of the efficiency of mollusks in detecting and storing residues of the persistent organochlorines, it is clear that relatively low levels of this type of pollution were present in the monitored areas during the period 1965 to 1972.

Appropriate correlations of the residue data reported here with available records of drainage-basin discharge rates, precipitation, and hydrographic factors in the various types of estuaries should provide a useful model for predicting the effects of future introductions of unspecified synthetic substances chemically similar to DDT.

See Appendix for chemical names of compounds discussed in this paper.

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The program could not have been developed without the interest and skills of Alfred J. Wilson, Jr., Research Chemist at the Gulf Breeze Laboratory.

Lastly, I thank the administrators and professional staffs of the cooperating agencies who kindly let me think that the monitoring program had the number one priority on their busy schedules.

In view of the volume of data in this report, it is inevitable that there are sins of both omission and commission. The writer would be most grateful to have these called to his attention so that the record can be appropriately emended.

COOPERATING AGENCIES—This alphabetical listing by States includes the names of investigators and, where appropriate, chemists and their titles at the time they were participating in the program. Where chemists are not listed, the samples were analyzed at the Gulf Breeze Laboratory under the supervision of Alfred J. Wilson, Jr., with the assistance of Jerrold Forrester and Johnny Knight. The listing of more than one principal investigator or agency in any one State reflects changes taking place during the monitoring period 1965-72. Operational funds were provided by the U.S.F.W.S., Bureau of Commercial Fisheries (BCF) for the collection of samples and for analytical equipment where contracts are indicated. In States participating by agreement, the BCF provided equipment and chemicals. In 1971-72, the program was jointly funded by the National Marine Fisheries Service (NMFS) and the Environmental Protection Agency.

ALABAMA	Alabama Marine Resources Laboratory Johnie H. Crance, Director; E. B. May, Principal Investigator. Agreement.
CALIFORNIA	California Dept. of Fish and Game, Marine Resources Operations Dr. H. C. Orcutt, Laboratory Supervisor; John Modin, Chemist. Contracts, BCF: 14-17-0007-332; 14-17-0002-211; -265; -337; -532. California Department of Fish and Game, Resources Agency W. H. Griffith, Principal Investigator. Contract, NMFS: N-042-10-72(N).
DELAWARE	University of Delaware Dr. F. C. Daiber, Principal Investigator. Contracts, BCF: 14-17-0002-117; -261; -326.
FLORIDA	State Board of Conservation Marine Laboratory R. M. Ingle, Director of Research. Agreement. Bureau of Commercial Fisheries—Environmental Protection Agency, Gulf Breeze Laboratory. Dr. T. W. Duke, Director. Agreement.
GEORGIA	The University of Georgia Dr. T. L. Linton, Principal Investigator. Contracts, BFC: 14-17-0002-220; -267. C. J. Durant, Principal Investigator and Chemist. Contracts, BFC: 14-17-0002-344; -454. Dr. R. J. Reimold, Principal Investigator. Contract, NMFS: N-042-12-71(N).
MAINE	Department of Sea and Shore Fisheries L. Varney, Principal Investigator; John Hurst, Laboratory Director and Chemist. Contracts, BCF: 14-17-0007-333; 14-17-0002-206; -263; -332; -434.
MARYLAND	BCF Biological Laboratory Dr. A. Rosenfield, Principal Investigator. Agreement.
MISSISSIPPI	Gulf Coast Research Laboratory Dr. W. P. Abbott, Principal Investigator. Contracts, BCF: 14-17-0002-133; -172; -235; -341. Dr. G. Gunter, Laboratory Director. Contract, NMFS: N-042-11-71(N).
NEW JERSEY	Rutgers—The State University, Oyster Research Laboratory Dr. H. H. Haskin and D. E. Kunkle, Principal Investigators. Agreement.
NEW YORK	New York State Department of Environmental Conservation D. H. Wallace, Director of Marine Fisheries; J. Foehrenbach, Chemist. Contracts, BCF: 14-17-0002-163; -219; -268; -345; -455; NMFS: N-042-14-71(N).
NORTH CAROLINA	University of North Carolina, Institute for Marine Sciences Dr. A. F. Chestnut, Principal Investigator. Contracts, BCF: 14-17-0002-182; -239; -343; NMFS: N-042-15-71(N).
SOUTH CAROLINA	Bears Bluff Laboratories, Inc. Dr. G. R. Lunz, Director (deceased). Contracts, BCF: 14-17-0002-130; -171; -234; -340; -426.
TEXAS	State of Texas, Parks and Wildlife Department T. R. Leary, Coastal Fisheries Coordinator; R. Childress, Principal Investigator. Agreement.
VIRGINIA	Virginia Institute of Marine Science Dr. M. L. Brehmer, Principal Investigator; Dr. R. J. Huggett, Principal Investigator and Chemist. Contracts, BCF: 14-17-0002-138; -174; -237; -342; -452; NMFS: N-042-13-71(N).
WASHINGTON	State of Washington, Department of Fisheries C. Lindsay, R. E. Westley, Principal Investigators. Contracts, BCF: 14-17-0002-134; -173; -236.

Part II. Residue Data—Individual States

The following sections present residue data for the 15 coastal States where estuarine mollusks were monitored for organochlorine residues. A map showing sampling sites in the respective States together with a discussion of the findings are included in each section.

SECTION A.—ALABAMA

Samples of the eastern oyster, *Crassostrea virginica,* were collected in Alabama at 3-month intervals during 1968-69 from four commercial reefs in or near Mobile Bay. Samples were processed at the Alabama Marine Resources Laboratory and mailed to the Gulf Breeze Laboratory for chemical analysis.

Approximate station locations are shown in Fig. A-1. Stations 1 and 2 on the eastern shore of Mobile Bay are influenced more by the presumably cleaner Gulf of Mexico waters than Stations 3 and 4 which are more exposed to drainage waters from the Alabama-Tombigbee River Basin. Both Stations 1 and 4 are influenced to an unknown extent by small drainage basins in the coastal areas of Alabama. A summary of data on organochlorine residues in the monitored species, *C. virginica,* is presented in Table A-1, and the distribution of residues in this species for each sampling station by date of collection in Table A-2. Many of these data have already been published by the cooperating agency (*10*).

All 33 samples contained detectable amounts of DDT, but the sampling series was conducted in Alabama for too few years to indicate annual trends in pollution levels. An earlier study of pesticide residues in Mobile Bay oysters (*7*) also reported a 100% incidence of DDT in 82 samples analyzed; however, maximum DDT residues at Shell Bank and Cedar Point reefs were 13 and 25 times higher in 1965 than those observed in this study in 1969. Because of differences in sample preparation in the two studies, 1965 residues could be expected to be only about 10% higher than the 1969 data had there been no change in DDT pollution levels in the bay. Alabama and New Jersey were the only States of the 15 monitored in which 100% of the samples contained detectable residues of DDT. The maximum level of DDT in Alabama oysters (616 ppb) was lower than residues found in four other States.

Dieldrin residues were small, but the 18% incidence was significantly higher than the average incidence for all States of 15%. The incidence and magnitude of dieldrin residues in the 1965 study (*7*) were significantly higher.

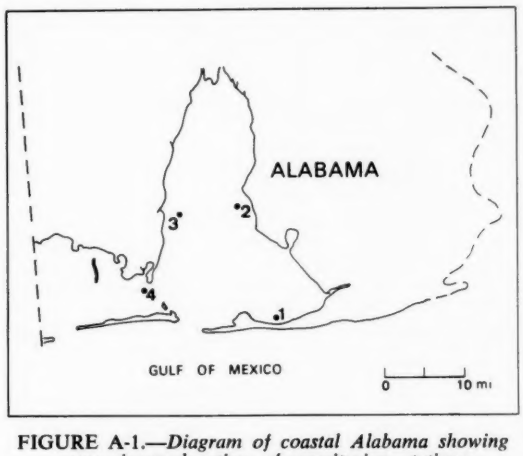

FIGURE A-1.—*Diagram of coastal Alabama showing approximate location of monitoring stations*

1. Shellbank—Bon Secour Bay
2. Klondike—Mobile Bay
3. Whitehouse—Mobile Bay
4. Cedar Point Reef—Mississippi Sound

TABLE A-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1968-69—Alabama*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
				DDT	Dieldrin
1	Shellbank	1968-69	8	8 (214)	1 (14)
2	Klondike	1968-69	8	8 (445)	1 (14)
3	White House	1968-69	7	7 (616)	2 (21)
4	Cedar Point	1968-69	8	8 (372)	2 (13)
	Occasional stations (2)	1968-69	2	2 (237)	
Total number of samples			33		
Percent of samples positive for indicated compound				100	18

[1] Each sample represents 15 or more mature mollusks.

TABLE A-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Alabama*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—SHELL BANK—8 SAMPLES[1]													
1968	DDE				110			110			33		
	TDE				88			52			15		
	DDT				16			12			—		
1969	DDE	48			94			48		26	T		
	TDE	31			70			25		17	T		
	DDT	—			—			—		13	—		
	Dieldrin	—			14			—		—	—		
STATION 2.—KLONDIKE—8 SAMPLES[1]													
1968	DDE				230			210			45		
	TDE				180			130			37		
	DDT				35			34			12		
1969	DDE	120			18			170		73	22		
	TDE	100			94			110		53	18		
	DDT	—			44			23		62	—		
	Dieldrin	—			14			—		—	—		
STATION 3.—WHITE HOUSE—7 SAMPLES[1]													
1968	DDE				320			120			32		
	TDE				240			57			20		
	DDT				56			11			—		
	Dieldrin				20			—			—		
1969	DDE	110			15			56		46			
	TDE	83			98			37		40			
	DDT	—			36			—		36			
	Dieldrin	—			21			—		—			
STATION 4.—CEDAR POINT—8 SAMPLES[1]													
1968	DDE				180			86			41		
	TDE				160			51			23		
	DDT				32			17			23		
1969	DDE	84			77			110		26	30		
	TDE	55			71			78		22	23		
	DDT	—			30			—		26	T		
	Dieldrin	—			13			—		—	T		

[1] Each sample represents 15 or more mature mollusks.

SECTION B.—CALIFORNIA

The monthly collection of mollusks to monitor pesticide pollution in 12 estuaries in California was initiated in January 1966. Some of these stations were terminated and other estuaries were added during the course of the program. Samples were analyzed at the Gulf Breeze Laboratory until May 1968; from then until May 1970 they were analyzed at the Marine Resources Operations Laboratory of the Department of Fish and Game, Menlo Park, Calif. During the period July 1970 - June 1972, samples were collected and analyzed at approximately 3-month intervals by the Department of Fish and Game, Pesticides Investigations at Sacramento, Calif.

Six different mollusks (*Crassostrea gigas, Corbicula fluminea, Modiolus denissus, Mytilus californianus, Mytilus edulis, and Ostrea lurida*) were utilized for monitoring; for the most part, a single species was collected at each station. The relative ability of these different mollusks to store organochlorine residues appears to be reasonably similar and, thus, comparisons of the magnitude of residues in different estuaries can be made with some confidence. In general, residue levels at different stations followed patterns of suspected pollution loading in the associated drainage basin, regardless of the species monitored.

The approximate station locations are shown in Fig. B-1. A summary of data on organochlorine residues in the monitored species is presented in Table B-1, and the distribution of residues in these species for each sampling station by date of collection in Table B-2. Results of some of the analyses conducted by the Gulf Breeze Laboratory during the period January 1966 - December 1967 have been published by the cooperating agency (*13*).

DDT residues in mollusks were consistently larger in California than in any other area monitored with the exception of a single station in south Florida. There is a clear pattern of maximum pesticide residues being correlated with proximity of the monitoring station to runoff from agricultural lands. In southern California, where most samples contained typically large residues, residues were consistently higher at Hedionda and Mugu Lagoons, the recipients of agricultural runoff waters, than at Anaheim Slough which receives intermittent runoff from the urban and industrialized sections of Los Angeles. Residues in samples from estuaries draining the intensely cultivated central and southern parts of the State were larger, by one order of magnitude usually, than those in samples collected from watersheds north of San Francisco Bay where dairy land predominates.

The incidence of dieldrin residues (25%) was second only to New York samples although residues were lower in magnitude than in five other States. California and Texas were the only States where endrin and toxaphene

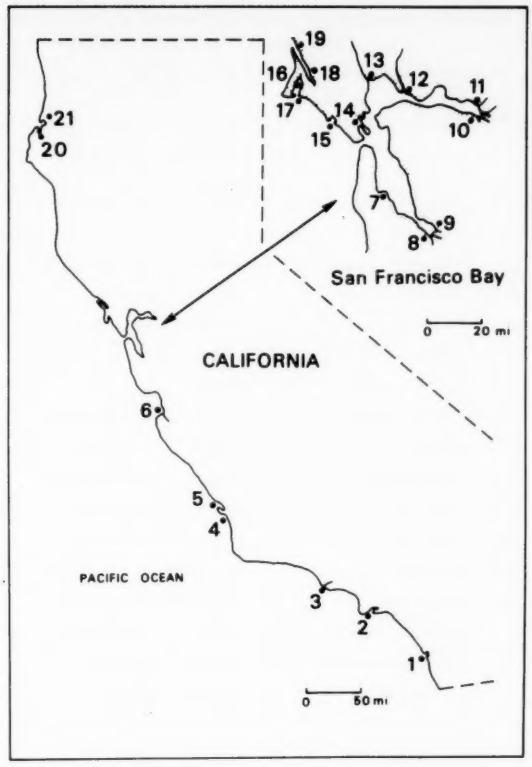

FIGURE B-1.—*Diagram of coastal California and the San Francisco Bay area showing approximate location of monitoring stations*

1. Hedionda Lagoon
2. Anaheim Slough
3. Point Mugu
4. Baywood Park—Morro Bay
5. Los Osos Creek—Morro Bay
6. Elkhorn Slough
7. Coyote Point—San Francisco Bay, South
8. Guadalupe Slough—San Francisco Bay, South
9. Alviso Slough—San Francisco Bay, South
10. West Island—Sacramento-San Joaquin River Basin
11. False River—Sacramento-San Joaquin River Basin
12. Napa River—San Pablo Bay
13. Petaluma River—San Pablo Bay
14. Point San Quentin—San Francisco Bay, North
15. Bolinas Lagoon
16. Schooner Bay—Drakes Estero
17. Berries Bay—Drakes Estero
18. Tomales Bay—Tomales Bay
19. Nicks Cove—Tomales Bay
20. Gunther Island—Humboldt Bay
21. Bird Island—Humboldt Bay

from presumably agricultural sources were detected. Polychlorinated biphenyl compounds were detected in samples beginning in 1971, but were not quantified. They occurred in a few samples from nearly all drainage basins monitored.

Late in 1970 or early 1971, there was a sharp decline in DDT residues in samples collected in estuaries draining predominantly agricultural areas, i.e., San Francisco Bay and the southern parts of the State. Decreased frequency

of sample collection in 1970-71 makes it impossible to pinpoint when this decline in DDT pollution occurred. The typically small DDT residues in samples from drainage basins north of San Francisco Bay remained about the same throughout the monitoring period.

TABLE B-1.—*Summary of data on organochlorine residues in the monitored species, 1966-72—California*

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)				
					DDT	Dieldrin	Endrin	Toxaphene	PCB's [2]
1	Hedionda Lagoon	1967-72	*M. edulis*	31	31 (3,970)	4 (T)		2 (11,000)	2
2	Anaheim Slough	1967-72	*M. edulis*	33	33 (833)	10 (31)	1 (T)		2
3	Point Mugu	1967-72	*M. edulis*	29	29 (1,758)	9 (16)	1 (T)		2
4	Baywood Park	1966-72	*C. gigas*	52	52 (601)	3 (24)			
5	Los Osos Creek	1966-72	*C. gigas*	52	52 (412)	4 (27)			1
6	Elkhorn Slough	1966-72	*C. gigas*	57	57 (2,305)	24 (57)	2 (19)		2
7	Coyote Point	1966-72	*O. lurida*	55	54 (362)	26 (43)	2 (19)		1
8	Guadalupe Slough	1968-72	*M. demissus*	27	25 (407)	9 (37)			1
9	Alviso Slough	1968-72	*M. demissus*	28	28 (328)	6 (25)			1
10	West Island	1967-72	*C. fluminea*	28	28 (2,280)	23 (22)	3 (T)		1
11	False River	1967-71	*C. fluminea*	26	26 (1,850)	12 (24)	1 (18)		
12	Napa River	1968-72	*M. demissus*	28	26 (210)	5 (T)	2 (T)		1
13	Petaluma River	1968-72	*M. demissus*	28	25 (268)	4 (10)			1
14	Point San Quentin	1966-70	*C. gigas*	50	49 (440)	22 (23)			
15	Bolinas Lagoon	1966-68	*C. gigas*	17	14 (45)				
16	Schooner Bay	1966-72	*C. gigas*	33	25 (43)	2 (T)			1
17	Berries Bar	1966-68	*C. gigas*	27	25 (44)		1 (19)		
18	Tomales Bay	1966-72	*C. gigas*	34	28 (45)	2 (T)	1 (T)		
19	Nicks Cove	1966-68	*C. gigas*	25	20 (37)				
20	Gunther Island	1966-72	*C. gigas*	33	31 (78)	5 (T)			1
21	Bird Island	1966-68	*C. gigas*	25	3 (T)				
	Occasional stations (15)	1966-72	Mixed	54	51 (1,144)	25 (26)		2 (1,000)	4
Total number of samples				772					
Percent of samples positive for indicated compound					92	25	2	<1	3

NOTE: T = >5 but <10 ppb.
[1] Each sample represents 15 or more mature mollusks.
[2] Present but not quantified.

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*

[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—HEDIONDA LAGOON—*M. EDULIS* UNLESS OTHERWISE INDICATED—31 SAMPLES [1]													
1967	DDE										100	[2] 130	[2] 90
	TDE										72	240	84
	DDT										130	3,600	740
	Toxaphene										—	11,000	970

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—HEDIONDA LAGOON—*M. EDULIS*, UNLESS OTHERWISE INDICATED—31 SAMPLES [1]—Continued													
1968	DDE	130	52	200	210	91	130	120	168	[3] 105	120	136	
	TDE	73	31	88	220	103	154	80	171	74	73	58	
	DDT	920	200	440	300	42	86	59	129	63	120	164	
1969	DDE	52	211	242	118	227	95		139	347	466	76	
	TDE	—	207	101	172	124	53		35	99	115	64	
	DDT	123	291	486	214	99	91		34	61	68	108	
1970	DDE											114	
	TDE											102	
	DDT											54	
	Dieldrin											T	
1971	DDE		19				36		54			18	
	TDE		11				58		56			13	
	DDT		16				T		285			10	
	Dieldrin		T				—		—			—	
	PCB's		—				—		—			[4]	
1972	DDE	14				31							
	TDE	T				31							
	DDT	10				10							
	Dieldrin	T				T							
	PCB's	—				[4]							
STATION 2.—ANAHEIM SLOUGH—*M. EDULIS*, UNLESS OTHERWISE INDICATED—33 SAMPLES [1]													
1967	DDE										360	330	200
	TDE										100	150	87
	DDT										85	120	120
1968	DDE	270	[5] 110	[3] 170	310	464	203	265	432	[3] 464	440	354	
	TDE	91	45	62	110	186	102	68	109	127	170	118	
	DDT	160	43	110	77	108	52	33	51	65	110	70	
	Dieldrin	—	31	—	—	—	T	T	—	—	12	—	
	Endrin	—	—	—	—	—	—	T	—	—	—	—	
1969	DDE	157	273	127	51	388	547	323	466	451	168	494	
	TDE	37	55	—	136	172	189	107	115	107	129	130	
	DDT	123	217	94	222	131	97	37	60	64	282	88	
1970	DDE		157									305	
	TDE		49									126	
	DDT		38									10	

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—ANAHEIM SLOUGH—*M. EDULIS*, UNLESS OTHERWISE INDICATED—33 SAMPLES [1]—Continued													
1971	DDE		75			103			185			92	
	TDE		53			164			101			41	
	DDT		23			T			22			10	
	Dieldrin		T			T			T			T	
	PCB's		—			—			—			[4]	
1972	DDE	64				80							
	TDE	24				53							
	DDT	18				10							
	Dieldrin	T				T							
	PCB's	—				[4]							
STATION 3.—POINT MUGU—*M. EDULIS*, UNLESS OTHERWISE INDICATED—29 SAMPLES [1]													
1967	DDE										130	160	220
	TDE										150	230	280
	DDT										270	440	650
	Dieldrin										—	—	T
1968	DDE	250	200	[3] 370	170	366	207	255	465	[3] 269		360	
	TDE	230	210	350	180	494	168	65	388	278		443	
	DDT	460	340	790	430	749	363	32	432	566		955	
	Dieldrin	—	—	16	—	—	—	T	—	—		T	
	Endrin	—	—	—	—	—	—	—	—	—		T	
1969	DDE	226		560	334	365	[6] 273	[6] 298		[6] 918	[6] 349	112	
	TDE	121		—	301	63	31	116		117	34	146	
	DDT	161		391	248	120	92	40		580	176	185	
1970	DDE											[6] 238	
	TDE											141	
	DDT											56	
1971	DDE		[6] 49				[6] 65		[6] 22			[6] 112	
	TDE		24				73		T			50	
	DDT		45				11		—			20	
	Dieldrin		T				T		—			T	
	PCB's		—				—		—			[4]	
1972	DDE	[6] 37				[6] 24							
	TDE	12				10							
	DDT	T				10							
	Dieldrin	T				T							
	PCB's	—				[4]							

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—BAYWOOD PARK—*C. GIGAS*—52 SAMPLES [1]													
1966	DDE	54	74	82	75	76	52	55	62	59	69	69	100
	TDE	26	34	35	25	32	19	22	25	35	34	33	37
	DDT	25	25	26	20	24	14	—	18	26	24	25	46
	Dieldrin	—	—	—	24	16	—	—	—	—	—	—	—
1967	DDE	110	110	62	130	80	120	51	82	55	48	35	46
	TDE	29	42	50	47	34	49	29	40	23	21	10	13
	DDT	58	73	96	130	67	70	37	49	46	26	15	10
1968	DDE	96	43	40	160	48	49	48	48	44		74	
	TDE	24	13	T	40	17	19	—	13	—		—	
	DDT	25	13	30	61	—	T	T	T	—		—	
1969	DDE	123	111	139	180	148	119	110		97	165	184	162
	TDE	23	38	—	70	57	40	57		31	53	70	75
	DDT	24	164	131	351	189	150	43		31	58	64	69
1970	DDE		220	226	215	56							
	TDE		74	87	58	21							
	DDT		69	64	46	—							
1971	DDE								22			21	
	TDE								11			16	
	DDT								—			10	
1972	DDE	33											
	TDE	12											
	DDT	T											
	Dieldrin	T											
STATION 5.—LOS OSOS CREEK—*C. GIGAS*, UNLESS OTHERWISE INDICATED—52 SAMPLES [1]													
1966	DDE	83	58	43	88	65	40	43	53	73	10	71	72
	TDE	33	27	17	39	25	16	16	22	34	27	33	31
	DDT	23	21	14	30	20	—	—	14	23	23	25	37
	Dieldrin	—	—	—	27	10	—	—	—	—	—	—	—
1967	DDE	62	120	63	110	93	130	64	81	56	43	37	29
	TDE	29	47	43	42	57	56	46	44	33	20	14	10
	DDT	41	96	130	120	92	80	52	49	72	25	20	12
1968	DDE	100	61	42	70	[7] 65	42	31	25	55		69	
	TDE	32	21	13	24	T	T	—	11	T		—	
	DDT	37	21	T	36	T	—	T	—	—		—	
1969	DDE	66	70	126	104	155	144	201		115	223		137
	TDE	T	37	—	56	61	80	83		43	72		51
	DDT	T	72	131	239	183	188	128		34	93		35

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—LOS OSOS CREEK—*C. GIGAS*, UNLESS OTHERWISE INDICATED—52 SAMPLES [1]—Continued													
1970	DDE		186	182	221	63							
	TDE		60	54	70	13							
	DDT		53	50	41	—							
1971	DDE								29			25	
	TDE								15			21	
	DDT								T			10	
1972	DDE	30				12							
	TDE	12				T							
	DDT	T				10							
	Dieldrin	T				T							
	PCB's	—				[4]							
STATION 6.—ELKHORN SLOUGH—*C. GIGAS*, UNLESS OTHERWISE INDICATED—57 SAMPLES [1]													
1966	DDE	160	220	96	96	89	88	86	72	79	84	130	190
	TDE	160	220	120	110	95	82	79	77	66	65	77	160
	DDT	250	290	110	96	85	65	64	55	41	56	76	210
	Dieldrin	—	19	11	20	18	—	—	—	—	10	—	30
1967	DDE	200	220	200	230	210	300	160	200	190	62	190	250
	TDE	160	230	200	260	340	390	200	260	210	55	150	230
	DDT	260	440	390	690	860	920	390	500	390	110	340	370
	Dieldrin	26	25	29	30	39	33	10	10	15	—	14	17
1968	DDE	260	130	120	170	214		173	122	168		95	65
	TDE	160	85	92	160	212		129	70	100		71	63
	DDT	250	97	61	230	411		237	159	200		113	110
	Dieldrin	13	—	—	—	—		27	—	—		—	—
	Endrin	—	—	—	—	—		19	—	—		—	—
1969	DDE	178	191	126	280	215	324	424			1,373	237	191
	TDE	102	338	156	393	223	253	358			502	171	117
	DDT	120	441	346	808	304	96	704			630	284	189
1970	DDE	208	230	445	270	353	325					[7] 31	
	TDE	173	300	582	285	276	236					19	
	DDT	204	444	808	491	411	375					26	
	Dieldrin	—	—	—	—	—	—					T	
	Endrin	—	—	—	—	—	—					T	
1971	DDE		[7] 67			[7] 29			[7] 43			[7] 28	
	TDE		37			24			71			37	
	DDT		72			10			—			17	
	Dieldrin		—			T			—			11	
	PCB's		—			—			—			[4]	

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 6.—ELKHORN SLOUGH—*C. GIGAS*, UNLESS OTHERWISE INDICATED—57 SAMPLES [1]—Continued													
1972	DDE		[7] 42			[7] T							
	TDE		25			T							
	DDT		36			10							
	Dieldrin		T			57							
	PCB's		—			[6]							
STATION 7.—COYOTE POINT—*O. LURIDA*—55 SAMPLES [1]													
1966	DDE	54	93	42	71	71	47	30	35	50	42	33	63
	TDE	74	120	54	88	91	66	38	46	65	71	51	79
	DDT	63	100	43	70	74	46	39	42	55	62	40	75
	Dieldrin	—	27	20	29	23	—	—	—	—	21	15	21
1967	DDE	41	49	51	61	65	52	51	47	39	33	46	46
	TDE	60	68	74	82	76	78	84	58	58	37	86	84
	DDT	58	72	79	89	69	70	80	50	50	43	110	51
	Dieldrin	26	26	28	23	21	25	17	43	13	—	16	16
	Endrin	—	—	—	—	—	19	—	—	—	—	—	—
1968	DDE	44	59	47	47	46	27	42	—	30		33	
	TDE	57	95	69	71	103	41	57	—	57		69	
	DDT	53	100	84	89	103	45	60	—	56		58	
	Dieldrin	13	—	18	20	—	—	10	—	—		—	
	Endrin	—	—	—	10	—	—	—	—	—		—	
1969	DDE	81	52	172	25	—	65	34	163	36		52	24
	TDE	46	—	—	—	89	87	38	99	T		78	30
	DDT	48	158	171	—	176	88	33	100	39		59	26
1970	DDE	18	33	102	93	37	33						
	TDE	33	55	102	100	—	50						
	DDT	33	42	87	76	42	24						
1971	DDE		17									14	
	TDE		67									24	
	DDT		47									24	
	Dieldrin		T									T	
1972	DDE		15			T							
	TDE		32			T							
	DDT		53			T							
	Dieldrin		T			T							
	PCB's		—			[6]							

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 8.—GUADALUPE SLOUGH—*M. DEMISSUS*—27 SAMPLES[1]													
1968	DDE		36	77	48	74	67	34	24	19	24	34	T
	TDE		90	180	100	185	140	68	53	57	58	T	24
	DDT		110	150	60	91	130	34	T	40	26	—	T
	Dieldrin		18	23	14	—	14	—	—	—	—	—	—
1969	DDE	—	—	34	70	26	11	10	24	—	29		
	TDE	42	—	—	—	27	108	22	34	48	50		
	DDT	—	—	—	—	—	204	T	T	T	T		
1970		No Samples Collected											
1971	DDE		T			T			—			T	
	TDE		40			26			—			T	
	DDT		28			10			—			10	
	Dieldrin		T			T			—			37	
1972	DDE		11			T							
	TDE		12			T							
	DDT		10			10							
	Dieldrin		T			T							
	PCB's		—			(4)							
STATION 9.—ALVISO SLOUGH—*M. DEMISSUS*—28 SAMPLES[1]													
1968	DDE		43	46	69	74	47	26	28	18	11	—	13
	TDE		140	59	170	169	95	72	80	45	79	T	30
	DDT		93	78	77	85	66	35	34	35	11	T	27
	Dieldrin		18	12	25	—	—	—	—	—	—	—	—
1969	DDE	38	—	55	98	52	12	17	30	—	39		
	TDE	59	61	55	—	73	161	42	45	56	27		
	DDT	—	—	88	—	108	111	T	20	T	T		
1970	DDE		42										
	TDE		76										
	DDT		33										
1971	DDE		13			T			—			T	
	TDE		38			15			T			T	
	DDT		17			T			—			10	
	Dieldrin		—			T			—			—	
1972	DDE	T				T							
	TDE	T				T							
	DDT	10				10							
	Dieldrin	T				T							
	PCB's	—				(4)							

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 10.—WEST ISLAND—*C. FLUMINEA*—28 SAMPLES [1]													
1967	DDE	280	330	320	270	320	230	170	140	170	180	690	390
	TDE	250	370	350	250	250	210	130	93	150	150	490	310
	DDT	210	300	310	250	260	270	150	130	230	270	1,100	770
	Dieldrin	20	20	22	17	12	18	T	15	20	10	20	18
	Endrin	T	T	T	—	—	—	—	—	—	—	—	—
1968	DDE	390	500	280	370	251	196	134	104	41		71	
	TDE	290	400	200	220	224	183	160	182	97		138	
	DDT	240	290	190	210	320	223	150	235	150		184	
	Dieldrin	16	22	15	16	—	21	19	13	—		—	
1969	DDE			177									
	TDE			—									
	DDT			168									
1970		No Samples Collected											
1971	DDE					198			91			15	
	TDE					126			71			T	
	DDT					173			111			—	
	Dieldrin					T			T			T	
1972	DDE		11			T							
	TDE		10			T							
	DDT		10			10							
	Dieldrin		—			T							
	PCB's		—			(4)							
STATION 11.—FALSE RIVER—*C. FLUMINEA*—26 SAMPLES [1]													
1967	DDE				470	460	320	420	270				400
	TDE				410	320	200	260	180				350
	DDT				970	910	640	780	500				210
	Dieldrin				24	19	20	16	16				17
1968	DDE	470	500	340	330	315	199	250	122	53		96	
	TDE	400	590	230	230	281	167	190	212	109		144	
	DDT	220	420	200	190	312	225	290	296	92		103	
	Dieldrin	17	22	19	23	—	—	—	16	—		—	
	Endrin	18	—	—	—	—	—	—	—	—		—	
1969	DDE		151	54		93	41	88	139	57	42	—	
	TDE		152	66		75	47	88	165	91	76	91	
	DDT		378	167		214	46	135	136	61	43	44	
1970		No Samples Collected											

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 11.—FALSE RIVER—*C. FLUMINEA*—26 SAMPLES [1]—Continued													
1971	DDE		21										
	TDE		41										
	DDT		20										
	Dieldrin		T										
STATION 12.—NAPA RIVER—*M. DEMISSUS*—28 SAMPLES [1]													
1968	DDE		T	25	21	24	23	15	21	18		T	
	TDE		22	46	72	100	83	38	42	62		24	
	DDT		T	26	39	45	47	—	23	18		T	
1969	DDE	10	—	100	62	—	10	13	T	—	T	12	
	TDE	30	—	48	—	—	24	45	30	58	24	37	
	DDT	T	—	—	—	—	T	T	T	—	T	T	
1970	DDE		11									16	
	TDE		33									93	
	DDT		T									46	
	Dieldrin		—									T	
	Endrin		—									T	
1971	DDE		27			13			T				T
	TDE		143			68			T				T
	DDT		41			10			T				T
	Dieldrin		T			T			—				—
	Endrin		T			—			—				—
1972	DDE		T			T							
	TDE		21			T							
	DDT		23			10							
	Dieldrin		T			T							
	PCB's		—			(6)							
STATION 13.—PETALUMA RIVER—*M. DEMISSUS*—28 SAMPLES [1]													
1968	DDE		—	27	27	26	47	19	—	—		92	
	TDE		—	58	63	72	104	35	T	13		68	
	DDT		—	15	19	31	41	T	—	—		108	
1969	DDE	T	—	124	49	12	T	17	—	—	22	10	
	TDE	T	—	37	—	28	T	38	—	57	37	22	
	DDT	—	—	—	—	—	T	T	—	—	T	T	
1970	DDE		T									28	
	TDE		T									71	
	DDT		T									26	
	Dieldrin		—									10	

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 13—PETALUMA RIVER—*M. DEMISSUS*—28 SAMPLES [1]—Continued													
1971	DDE		T			T			—				T
	TDE		18			24			T				T
	DDT		10			T			—				—
	Dieldrin		T			—			—				—
1972	DDE		T			T							
	TDE		T			T							
	DDT		10			10							
	Dieldrin		T			T							
	PCB's		—			(4)							
STATION 14.—POINT SAN QUENTIN—*C. GIGAS*—50 SAMPLES [1]													
1966	DDE	12	30	47	52	69	59	37	52	57	51	55	55
	TDE	20	37	60	83	120	92	47	82	90	88	84	110
	DDT	14	12	19	23	45	38	24	43	49	33	40	98
	Dieldrin	—	—	—	14	20	—	—	—	—	11	15	20
1967	DDE	52	34	30	42	23	39	45	53	30	31	100	45
	TDE	130	65	59	75	55	85	120	130	74	68	50	84
	DDT	88	49	49	70	34	64	89	63	38	36	85	45
	Dieldrin	23	11	15	19	13	21	19	17	11	—	10	11
1968	DDE	43	44	43	43	36	59	59	25	38			40
	TDE	79	96	78	97	95	110	110	60	86			120
	DDT	44	89	67	63	69	100	100	T	52			82
	Dieldrin	12	17	17	12	—	—	12	—	—			18
1969	DDE	74	53	62	47	143	25	13	30		—	—	31
	TDE	80	149	134	—	143	54	23	41		—	55	51
	DDT	130	193	76	182	154	24	T	T		—	32	26
1970	DDE	18	19	54	66	51							
	TDE	18	T	31	64	39							
	DDT	T	T	37	45	23							
STATION 15.—BOLINAS LAGOON—*C. GIGAS*—17 SAMPLES [1]													
1966	DDE									10	T	T	—
	TDE									—	T	10	—
	DDT									—	—	—	—
1967	DDE	T	T	10	10	11	T	11	13	—	T	T	T
	TDE	11	13	16	17	16	14	21	20	—	15	11	T
	DDT	T	T	T	11	14	12	13	11	—	11	—	—

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 15.—BOLINAS LAGOON—*C. GIGAS*—17 SAMPLES [1]—Continued													
1968	DDE	—											
	TDE	—											
	DDT	—											
STATION 16.—SCHOONER BAY—*C. GIGAS*—33 SAMPLES [1]													
1966	DDE	—	T	T	—	T	T	T	T	—	T	T	—
	TDE	—	—	T	—	T	—	—	—	—	T	T	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	T	T	10	11	T	11	T	15	—	—	T	—
	TDE	—	—	T	13	13	13	T	18	—	—	—	—
	DDT	—	—	—	10	—	T	—	10	—	—	—	—
1968	DDE	—											
	TDE	—											
	DDT	—											
1969		No Samples Collected											
1970	DDE		11									10	
	TDE		T									11	
	DDT		T									10	
1971	DDE		14			T			T				T
	TDE		16			T			T				T
	DDT		10			T			T				10
	Dieldrin		T			—			—				—
1972	DDE		T			T							
	TDE		T			T							
	DDT		10			10							
	Dieldrin		—			T							
	PCB's		—			[4]							
STATION 17.—BERRIES BAR—*C. GIGAS*—27 SAMPLES [1]													
1966	DDE	—	13	T	10	13	10	17	11	12	T	T	11
	TDE	—	15	T	17	16	10	13	11	T	T	T	10
	DDT	—	T	—	—	T	—	—	—	—	—	—	—
1967	DDE	T	11	17	14	16	12	13	T	13	15	14	T
	TDE	T	14	20	18	17	14	15	12	16	18	17	T
	DDT	—	—	T	10	11	10	T	—	10	T	T	—

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 17—BERRIES BAR—*C. GIGAS*—27 SAMPLES[1]—Continued													
1968	DDE	—			12				17				
	TDE	—			13				14				
	DDT	—			T				—				
	Endrin	19			—				—				
STATION 18.—TOMALES BAY—*C. GIGAS*—34 SAMPLES[1]													
1966	DDE	T	T	—	—	T	—	14	11	14	14	T	T
	TDE	—	T	—	—	11	—	T	T	11	12	—	—
	DDT	—	—	—	—	T	—	—	—	—	—	—	—
1967	DDE	T	12	11	11	T	11	T	T	T	—	11	—
	TDE	—	T	T	12	T	14	T	—	—	—	T	—
	DDT	T	10	T	11	T	13	T	—	—	—	T	—
1968	DDE	—			11				T				
	TDE	—			—				T				
	DDT	—			10				—				
1969	DDE									22		T	
	TDE									T		T	
	DDT									18		T	
1970	DDE											T	
	TDE											T	
	DDT											10	
	Dieldrin											T	
	Endrin											T	
1971	DDE		12			T							T
	TDE		T			T							T
	DDT		10			10							10
1972	DDE		T										
	TDE		T										
	DDT		10										
	Dieldrin		T										
STATION 19.—NICKS COVE—*C. GIGAS*—25 SAMPLES[1]													
1966	DDE	—	12	11	—	T	T	11	11	T	T	T	T
	TDE	—	T	—	—	—	—	—	T	—	—	T	—
	DDT	—	T	—	—	—	—	—	—	—	—	—	—
1967	DDE	12	13	13	14	10	T	11	T	T	—	14	—
	TDE	T	10	12	12	T	T	T	—	T	—	—	—
	DDT	T	11	T	11	T	T	T	—	—	—	—	—

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 19—NICKS COVE—*C. GIGAS*—25 SAMPLES [1]—Continued													
1968	DDE	—											
	TDE	—											
	DDT	—											
STATION 20.—GUNTHER ISLAND—*C. GIGAS*—33 SAMPLES [1]													
1966	DDE	—	—	—	—	—	T	11	T	T	T	T	T
	TDE	—	—	—	—	—	T	17	—	21	T	T	T
	DDT	T	10	—	47	11	14	—	11	—	18	14	20
1967	DDE	10	T	T	T	T	T	T	T	—	T	T	T
	TDE	T	—	—	T	—	T	T	—	T	T	T	T
	DDT	30	28	12	19	19	19	24	12	16	15	21	22
1968	DDE	—			13								
	TDE	—			11								
	DDT	—			54								
1969		No Samples Collected											
1970	DDE											11	
	TDE											11	
	DDT											10	
	Dieldrin											T	
1971	DDE		T			T			T				T
	TDE		13			T			—				T
	DDT		17			10			—				10
	Dieldrin		T			T			—				T
1972	DDE			T			T						
	TDE			T			T						
	DDT			10			10						
	Dieldrin			—			T						
	PCB's			—			(4)						
STATION 21.—BIRD ISLAND—*C. GIGAS*—25 SAMPLES [1]													
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	T	—	—	T	—	T

TABLE B-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—California*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 21—BIRD ISLAND—*C. GIGAS*—25 SAMPLES [1]—Continued													
1968	DDE	—											
	TDE	—											
	DDT	—											

[1] Each sample represents 15 or more mature mollusks.
[2] DDE, TDE, and DDT values approximated because of presence of toxaphene.
[3] *C. gigas*.
[4] Present but not quantified.
[5] *M. demissus*.
[6] *M. californianus*.
[7] *M. edulis*.

SECTION C.—DELAWARE

Samples were collected at nine stations at monthly intervals during the period October 1966 - August 1969. The eastern oyster (*Crassostrea virginica*) ribbed mussel (*Modiolus demissus*), and hard clam (*Mercenaria mercenaria*) were each collected at three stations. All samples were analyzed at the Gulf Breeze Laboratory. The approximate locations of the stations are shown in Fig. C-1. The Cape Henlopen station was in Delaware Bay; the other stations were adjacent to the Bay but exposed primarily to the runoff from large agricultural areas in separate drainage basins. A summary of data on organochlorine residues in the monitored species is presented in Table C-1, and the distribution of residues in these species for each sampling station by date of collection in Table C-2.

The use of three different species for monitoring obscured pollution patterns in Delaware estuaries to some extent. The relative inefficiency of hard clams in storing organochlorine residues makes Rehoboth Bay (Stations 7 and 8) appear to be generally free from this type of pollution. The first samples of clams collected in adjacent Indian River Bay (Station 9) also were free of detectable residues; however, subsequent monitoring, using the ribbed mussel, showed Indian River Bay to be moderately but continuously polluted. It is probable that Rehoboth Bay was similarly polluted during the monitoring period. This same reasoning suggests that the waters at Cape Henlopen were continually more polluted with DDT than the small residues in the hard clams would imply.

The magnitude of DDT residues in clams and oysters showed no trend towards increased or decreased levels during the 3-year monitoring period. In ribbed mussels, however, there was a marked decline in the average level of residues in the final year at Stations 1 and 2 as well as Station 9. Delaware monitoring samples ranked 6th in frequency and 10th in magnitude of DDT residues in comparison with the other 14 States. The 13% incidence of dieldrin residues was about the average for all States.

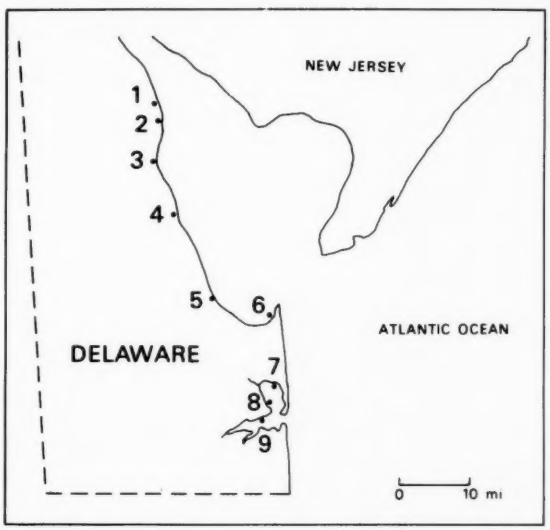

FIGURE C-1.—*Diagram of coastal Delaware showing approximate location of monitoring stations*

1. Leipsic River
2. Simons River
3. Bowers Beach—Murderkill River
4. Mispillion River
5. Broadkill River
6. Cape Henlopen—Delaware Bay
7. Thompson Island—Rehoboth Bay
8. Arrowhead Point—Rehoboth Bay
9. West Gables—Indian River Bay

TABLE C-1.—*Summary of data on organochlorine residues in the monitored species, 1966-69—Delaware*

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
					DDT	Dieldrin
1	Leipsic River	1967-69	M. demissus	27	23 (156)	4 (13)
2	Simons River	1967-69	M. demissus	25	23 (205)	6 (19)
3	Bowers Beach	1966-69	C. virginica	34	34 (172)	25 (25)
4	Mispillion River	1966-69	C. virginica	35	33 (90)	2 (10)
5	Broadkill River	1966-69	C. virginica	34	34 (90)	
6	Cape Henlopen	1966-69	M. mercenaria	32	30 (65)	
7	Thompson Island	1966-69	M. mercenaria	33	5 (16)	
8	Arrowhead Point	1966-69	M. mercenaria	34	4 (35)	
9	West Gables	1966-69	M. demissus	33	30 (96)	
Total number of samples				287		
Percent positive for indicated compound					75	13

[1] Each sample represents 15 or more mature mollusks.

TABLE C-2—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Delaware*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—LEIPSIC RIVER—*M. DEMISSUS*—27 SAMPLES [1]													
1967	DDE			12	25	26	47	33	21	17	22	18	32
	TDE			11	53	46	91	77	51	47	29	47	77
	DDT			—	T	12	18	23	51	47	—	T	17
	Dieldrin			—	10	13	—	10	—	10	—	—	—
1968	DDE			27	30	32	26	33	T	12	23	19	
	TDE			68	69	91	41	45	20	18	29	37	
	DDT			17	17	14	—	22	—	—	T	18	
1969	DDE	—	—	T	15	T	—	17	—				
	TDE	—	—	14	18	T	—	33	—				
	DDT	—	—	—	—	—	—	19	—				
STATION 2.—SIMONS RIVER—*M. DEMISSUS*—25 SAMPLES [1]													
1967	DDE	13		17	31	31	43	37	25		18	29	29
	TDE	43		37	65	150	89	79	47		88	75	66
	DDT	—		—	15	24	19	28	38		29	18	16
	Dieldrin	—		—	15	19	12	T	—		12	—	—
1968	DDE			28	23	39			23	—	20	11	
	TDE			65	78	100			30	—	26	16	
	DDT			18	39	16			—	—	22	—	
	Dieldrin			—	—	10			—	—	—	—	

TABLE C-2—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Delaware*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—SIMONS RIVER—*M. DEMISSUS*—25 SAMPLES [1]—Continued													
1969	DDE	—	13	T	21	14	21	13	21				
	TDE	—	22	T	23	19	29	26	35				
	DDT	—	—	—	—	—	24	26	31				
STATION 3.—BOWERS BEACH—*C. VIRGINICA*—34 SAMPLES [1]													
1966	DDE											25	19
	TDE											29	17
	DDT											—	—
	Dieldrin											16	—
1967	DDE	27	25	[2]	[2]	42	43	41	40	40	42	41	32
	TDE	35	26	[2]	[2]	65	70	66	64	56	98	51	38
	DDT	—	—	[2]	[2]	T	10	24	68	17	25	14	10
	Dieldrin	18	14	20	25	24	18	11	13	16	16	13	15
1968	DDE	50	46	48	52	66	75	82	49	41	52	57	41
	TDE	56	42	47	48	73	78	53	34	32	44	57	35
	DDT	T	—	T	—	10	T	25	T	T	13	18	T
	Dieldrin	12	13	14	15	12	16	—	—	—	—	16	15
1969	DDE	52	48	42	49	41	79	60	39				
	TDE	37	47	36	39	39	70	57	29				
	DDT	—	—	—	—	—	20	29	11				
	Dieldrin	14	15	11	—	11	—	—	—				
STATION 4.—MISPILLION RIVER—*C. VIRGINICA*—35 SAMPLES [1]													
1966	DDE										31	21	22
	TDE										27	24	24
	DDT										15	—	—
1967	DDE	17	24	[2]	25	35	23	22	16	20	T	32	27
	TDE	18	22	[2]	31	41	26	30	20	23	44	36	32
	DDT	—	—	[2]	—	—	—	T	11	T	T	—	T
	Dieldrin	—	—	10	—	10	—	—	—	—	—	—	—
1968	DDE	23	28	Lost	41	39	39	47	34	32	25	39	38
	TDE	40	31		40	36	34	33	23	25	18	32	27
	DDT	T	—		—	15	—	—	—	—	—	—	—
1969	DDE	40	50	36	29	36	26	35	28				
	TDE	29	31	28	25	32	26	22	20				
	DDT	—	—	—	—	—	—	—	—				

TABLE C-2—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Delaware*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—BROADKILL RIVER—*C. VIRGINICA*—34 SAMPLES[1]													
1966	DDE										18	22	
	TDE										20	17	
	DDT										T	—	
1967	DDE	28	18	23	17	23	24	16	30	27	35	35	37
	TDE	23	11	17	13	18	21	19	30	27	27	31	33
	DDT	—	—	—	—	—	T	T	16	11	T	T	T
1968	DDE	25	29	23	32	39	43	36	48	37	31	44	51
	TDE	21	22	16	21	45	32	20	32	25	22	33	39
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	40	38	43	41	39	42	43	35				
	TDE	24	28	26	20	28	28	24	15				
	DDT	—	—	—	—	—	—	—	—				
STATION 6.—CAPE HENLOPEN—*M. MERCENARIA*—32 SAMPLES[1]													
1966	DDE											12	
	TDE											11	
	DDT											—	
1967	DDE	12	13	—	[2]	14	12	20	12	T	14	16	16
	TDE	16	12	—	[2]	14	14	24	14	T	13	15	15
	DDT	—	—	—	[2]	—	—	—	—	—	—	—	—
1968	DDE	13	15	18	18	28	39	25	25	19	13	T	21
	TDE	12	14	14	15	24	26	16	15	12	T	T	11
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	12	14	22	Lost	16	19	22	35				
	TDE	—	—	T		11	T	10	20				
	DDT	—	—	—		—	—	—	—				
STATION 7.—THOMPSON ISLAND—*M. MERCENARIA*—33 SAMPLES[1]													
1966	DDE										—		T
	TDE										T		11
	DDT										T		—
1967	DDE	T		—	T	T	—	—	—	—	—	—	—
	TDE	T		—	—	T	—	—	—	—	—	—	—
	DDT	—		—	—	T	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE C-2—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Delaware*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—THOMPSON ISLAND—*M. MERCENARIA*—33 SAMPLES [1]—Continued													
1969	DDE	—	—	—	—	—	—	—	—				
	TDE	—	—	—	—	—	—	—	—				
	DDT	—	—	—	—	—	—	—	—				
STATION 8.—ARROWHEAD POINT—*M. MERCENARIA*—34 SAMPLES [1]													
1966	DDE										—	—	T
	TDE										24	—	T
	DDT										11	—	—
1967	DDE	—		(2)	T	—	—	—	—	—	—	—	—
	TDE	—		(2)	T	—	—	—	—	—	—	—	—
	DDT	—		(2)	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—				
	TDE	—	—	—	—	—	—	—	—				
	DDT	—	—	—	—	—	—	—	—				
STATION 9.—WEST GABLES—*M. DEMISSUS* UNLESS OTHERWISE INDICATED—33 SAMPLES [1]													
1966	DDE										(3)	(3)	
	TDE										—	—	
	DDT										—	—	
1967	DDE	11		18	17	22	19	15	18	13	19	19	21
	TDE	25		37	32	33	24	21	29	13	29	30	33
	DDT	32		19	14	24	13	14	41	21	21	22	26
1968	DDE	19	24	18	20	18	23	T	T	—	T	12	13
	TDE	29	35	28	32	30	37	11	T	—	T	16	18
	DDT	21	30	22	26	23	36	T	—	—	—	T	—
1969	DDE	10	16	13	16	17	21	13	[3] 11				
	TDE	14	16	17	20	22	27	18	T				
	DDT	—	—	—	T	10	T	11	—				

[1] Each sample represents 15 or more mature mollusks.
[2] Present but not quantified.
[3] *M. mercenaria.*

SECTION D.—FLORIDA

Investigation of the effects of pesticide pollution on estuarine fauna in Florida was initiated at the Gulf Breeze Laboratory, Gulf Breeze, Fla., in 1959. During the next 5 years, sufficient headway in the understanding of uptake and flushing rates of persistent synthetic compounds as well as the technology for handling samples made a continuing monitoring program feasible. Local oysters (Station 9, East Bay) were analyzed monthly during 1964, and the concept of a national monitoring program was developed and implemented in 1965. The eastern oyster, *C. virginica*, was the only species monitored in Florida; all samples were analyzed at the Gulf Breeze Laboratory. The approximate locations of monitoring stations are shown in Fig. D-1. A summary of data on organochlorine residues in the monitored species, *C. virginica*, is presented in Table D-1, and the distribution of residues in this species for each sampling station by date of collection in Table D-2.

Oyster samples from Florida contained the highest levels of DDT residues and the most persistent contamination with PCB's observed in the entire monitoring program.

The polychlorinated biphenyl, Aroclor 1254®, was identified in studies of estuarine fauna following a 1969 fish kill in Escambia Bay, Fla., (*8*). Station 9 is about 25 miles from the presumed source of this PCB pollution and is in a contiguous but distinct drainage basin. Monitoring samples from this station contained PCB residues about one-third the magnitude of residues in Escambia Bay oysters and continued to have residues of similar magnitude for at least 3 years after the presumed primary source of PCB's had been eliminated.

The trend in DDT residues is most clearly shown in the Station 9 data. Some DDT had been used in this geographic area for agricultural purposes. However, its primary use had been for the control of stable-fly larvae, *Stomoxys calcitrans*, that develop in seaweed windrows on estuarine beaches. In 1969, methoxychlor was substituted for this purpose, and DDT residues virtually disappeared from all succeeding monitoring samples. Methoxychlor residues were not detected in the monitored samples. There are not enough recent data to determine DDT pollution trends in other estuaries along the Florida Gulf coast.

The incidence of DDT in Florida samples (62%) is about the average for all States monitored. The incidence of dieldrin (7%) may be compared with the average incidence of 15% for all States.

FIGURE D-1.—*Diagram of coastal Florida showing approximate location of monitoring stations*

1. Iona Point—Caloosahatchee River
2. Charlotte Harbor—Peace River
3. Coral Cove—Little Sarasota Bay
4. Manatee River
5. Crystal River
6. Suwanee River
7. St. Vincents Bar (North)—Apalachicola Bay
8. St. Vincents Bar (South)—Apalachicola Bay
9. East Bay—Blackwater River

TABLE D-1.—*Summary of data on organochlorine residues in the monitored species* (C. Virginica), *1965-72—Florida*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)		
				DDT	Dieldrin	PCB's [2]
1	Iona Point	1967-69	31	31 (5,390)	1 (11)	
2	Charlotte Harbor	1966-69	31	28 (338)	13 (27)	
3	Coral Cove	1966-69	32	32 (129)		
4	Manatee River	1966-69	32	32 (159)		
5	Crystal River	1966-71	43	7 (27)		
6	Suwanee River	1966-69	32	6 (22)		

TABLE D-1.—*Summary of data on organochlorine residues in the monitored species* (C. Virginica), *1965-72—Florida*—Continued

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)		
				DDT	Dieldrin	PCB's [2]
7	St. Vincents Bar (North)	1966-67	17	12 (50)	3 (28)	
8	St. Vincents Bar (South)	1966-67	16	10 (70)	3 (22)	
9	East Bay	1965-72	84	46 (65)		25 (390)
	Occasional stations (21)	1966-71	56	26 (101)	7 (12)	
Total number of samples			374			
Percent of samples positive for indicated compound				62	7	7

[1] Each sample represents 15 or more mature mollusks.
[2] Calculated as Aroclor 1254®.

TABLE D-2—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Florida*
[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—IONA POINT—31 SAMPLES [1]													
1966	DDE								30	13	24	35	T
	TDE								39	20	48	79	T
	DDT								—	—	—	28	—
1967	DDE	91	320	930	1,450	290	110	53	60	87	72	140	240
	TDE	94	170	760	705	310	200	110	160	160	150	220	310
	DDT	190	630	3,700	2,550	350	68	57	32	97	110	68	520
1968	DDE	760	1,200	1,100	1,500	780	340	180	—	T	77	84	82
	TDE	44	560	580	560	390	310	190	T	16	160	120	120
	DDT	2,800	3,600	2,300	1,200	650	220	33	—	—	69	140	60
	Dieldrin	—	—	—	—	—	—	—	—	11	—	—	—
1969	DDE		710	940									
	TDE		1,400	400									
	DDT		1,700	1,100									
STATION 2.—CHARLOTTE HARBOR—31 SAMPLES [1]													
1966	DDE								T	T	17	—	52
	TDE								10	16	23	—	91
	DDT								—	—	15	—	41
1967	DDE	83	14	15	39	18	30	13	T	T	—	T	18
	TDE	85	20	24	33	27	43	20	13	T	—	11	28
	DDT	170	T	13	—	T	13	T	—	—	—	—	21
	Dieldrin	—	—	—	—	—	—	14	11	19	—	—	15

TABLE D-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Florida*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—CHARLOTTE HARBOR—31 SAMPLES [1]—Continued													
1968	DDE	19	23	18	34	27	22	20	—	T	—	T	T
	TDE	22	28	18	36	29	18	26	T	17	—	11	T
	DDT	14	13	—	20	16	10	T	—	—	—	—	—
	Dieldrin	—	11	—	18	11	—	27	—	16	—	13	19
1969	DDE		14	17									
	TDE		19	22									
	DDT		—	12									
STATION 3.—CORAL COVE—32 SAMPLES [1]													
1966	DDE								24	T	10	25	17
	TDE								21	—	T	33	16
	DDT								—	—	—	T	T
1967	DDE	34	26	24	25	20	24	25	23	12	16	13	10
	TDE	28	23	22	26	21	21	24	20	16	16	10	10
	DDT	12	12	T	13	T	10	17	T	T	T	T	T
1968	DDE	29	27	21	35	49	39	31	19	20	28	21	23
	TDE	30	30	14	36	43	40	26	16	23	28	23	29
	DDT	10	14	—	13	37	49	32	22	14	28	11	T
1969	DDE	30	41	36									
	TDE	38	40	40									
	DDT	T	20	15									
STATION 4.—MANATEE RIVER—32 SAMPLES [1]													
1966	DDE								23	37	25	T	30
	TDE								39	47	33	T	33
	DDT								—	13	11	—	12
1967	DDE	37	39	22	31	18	T	19	21	23	33	34	13
	TDE	30	45	24	41	23	T	20	42	46	59	45	14
	DDT	19	19	10	13	T	—	T	20	17	13	14	14
1968	DDE	26	24	18	42	16	18	31	16	18	18	17	24
	TDE	24	29	30	65	19	61	88	37	38	16	19	27
	DDT	26	13	10	22	T	25	40	T	13	—	—	14
1969	DDE	22	32	24									
	TDE	33	46	26									
	DDT	—	17	T									

TABLE D-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Florida*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—CRYSTAL RIVER—43 SAMPLES[1]													
1966	DDE							—	12	—	—	T	—
	TDE							—	—	—	—	T	—
	DDT							—	—	—	—	—	—
1967	DDE	—	T	—	—	—	—	T	—	—		—	—
	TDE	—	—	—	—	—	—	T	—	—		—	—
	DDT	—	—	—	—	13	—	T	—	—		—	—
1968	DDE	—	—	—	T	—	11	—		—	—	—	—
	TDE	—	—	—	T	—	—	—		—	—	—	—
	DDT	—	—	—	—	—	16	—		—	—	—	—
1969	DDE	—	—	—			—		—		—		—
	TDE	—	—	—			—		—		—		—
	DDT	—	—	—			—		—		—		—
1970	DDE		—		—		—		—		—		—
	TDE		—		—		—		—		—		—
	DDT		—		—		—		—		—		—
1971	DDE	—			—								
	TDE	—			—								
	DDT	—			—								
STATION 6.—SUWANEE RIVER—32 SAMPLES[1]													
1966	DDE							—	T	—	—	T	—
	TDE							—	—	—	—	T	—
	DDT							—	—	—	—	—	—
1967	DDE	—	12	T	—	—	—	—	—	—	—	—	—
	TDE	—	T	T	—	—	—	—	—	—	—	—	—
	DDT	—	T	T	—	11	11	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—		—	—	—	—
	TDE	—	—	—	—	—	—	—		—	—	—	—
	DDT	—	—	—	—	—	—	—		—	—	—	—
1969	DDE	—	—	—									
	TDE	—	—	—									
	DDT	—	—	—									
STATION 7.—ST. VINCENTS BAR (NORTH)—17 SAMPLES[1]													
1966	DDE			T	16	T			14	—	—	11	T
	TDE			T	19	T			15	—	—	10	T
	DDT			—	T	—			—	—	—	—	—
	Dieldrin			—	10	—			—	—	—	—	—

TABLE D-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Florida*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—ST. VINCENTS BAR (NORTH)—17 SAMPLES [1]—Continued													
1967	DDE	T	—	T		22	T	13	—	—		T	
	TDE	—	—	T		23	T	10	—	—		—	
	DDT	—	—	—		T	—	T	—	—		—	
	Dieldrin	11	—	—		28	—	—	—	—		—	
STATION 8.—ST. VINCENTS BAR (SOUTH)—16 SAMPLES [1]													
1966	DDE			18	25				17	—	—	—	—
	TDE			21	30				T	—	—	—	—
	DDT			—	15				—	—	—	—	—
	Dieldrin			—	13				—	—	—	—	—
1967	DDE	T	—	14		21	T	13	T	T		—	
	TDE	—	—	13		22	T	12	T	—		—	
	DDT	—	—	—		T	38	T	—	—		—	
	Dieldrin	—	—	15		22	—	—	—	—		—	
STATION 9.—EAST BAY—84 SAMPLES [1]													
1965	DDE							19	T	T	—	T	T
	TDE							18	T	T	—	T	—
	DDT							13	T	T	—	T	—
1966	DDE	12	13	13	17	26	24	15	14	T	—	T	T
	TDE	—	14	—	15	24	19	11	—	—	—	—	T
	DDT	—	—	—	15	15	14	—	—	—	—	—	—
1967	DDE	T	18	21	18	18	12	20	T	T	T	T	T
	TDE	—	18	17	22	24	13	23	—	—	—	—	—
	DDT	—	14	16	15	15	—	18	—	10	—	—	—
1968	DDE	16	12	17	22	15	15	—	T	20	—	T	—
	TDE	15	20	—	—	—	—	—	T	—	—	—	—
	DDT	10	12	—	—	—	—	—	—	—	—	—	—
1969	DDE	T	16	11	—	13	14	—	—	10	T	—	—
	TDE	T	14	10	—	13	—	—	—	T	—	—	—
	DDT	—	T	—	—	—	—	—	—	14	—	—	—
1970	DDE	—	T	—	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	PCB's [2]	—	—	—	—	380	180	170	73	92	50	55	140
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	PCB's [2]	160	160	200	220	230	390	190	230	100	55	120	—

TABLE D-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Florida*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 9.—EAST BAY—84 SAMPLES [1]—Continued													
1972	DDE	—	—	—	—	—	—						
	TDE	—	—	—	—	—	—						
	DDT	—	—	—	—	—	—						
	PCB's [2]	50	82	140	160	190	300						

[1] Each sample represents 15 or more mature mollusks.
[2] Calculated as Aroclor 1254®.

SECTION E.—GEORGIA

Monthly collections of the eastern oyster (*C. virginica*) were made at 11 estuarine areas in Georgia during the period February 1967 - June 1972. Analyses were done at the Gulf Breeze Laboratory until September 1969, and thereafter at the Marine Institute of the University of Georgia. The approximate locations of monitoring stations are shown in Fig. E-1. A summary of data on organochlorine residues in the monitored species, *C. virginica*, is presented in Table E-1, and the distribution of residues in this species for each sampling station by date of collection in Table E-2. The 15% incidence of DDT residues in Georgia samples was next to the lowest of all States monitored (Washington, lowest at 11%). The maximum level of DDT observed was also next to the lowest of any of the other States monitored. By contrast, the largest dieldrin residue detected in the nationwide program was in Georgia, (230 ppb) and the incidence of dieldrin residues (21%) was well above the average incidence (15%) for all States.

The occurrence of substantial toxaphene residues in the samples collected in St. Simons Sound was unexpected. A special sampling program was initiated in the area that included the placement of trays of oysters in creek beds where oysters did not normally occur. Analyses of these samples pinpointed the industrial source of the toxaphene and precipitated a schedule for control of the effluent discharge by the manufacturer. The magnitude of toxaphene residues at Stations 8 - 11 illustrates well the importance of dilution (distance) in the abatement of pollution.

Polychlorinated biphenyl residues were analyzed for beginning in 1969. A few samples collected in the Ogeechee and Satilla River basins contained residues of Aroclor 1254®, but the amounts were not quantified.

DDT residue levels were generally low and there was an approximate increase of 13% in the number of samples with negligible residues in 1971 as compared to earlier years. Stations 1 and 2 in the Savannah River basin, however, showed a reversal of this trend in 1972 when oysters contained substantially higher residue levels than in 1971.

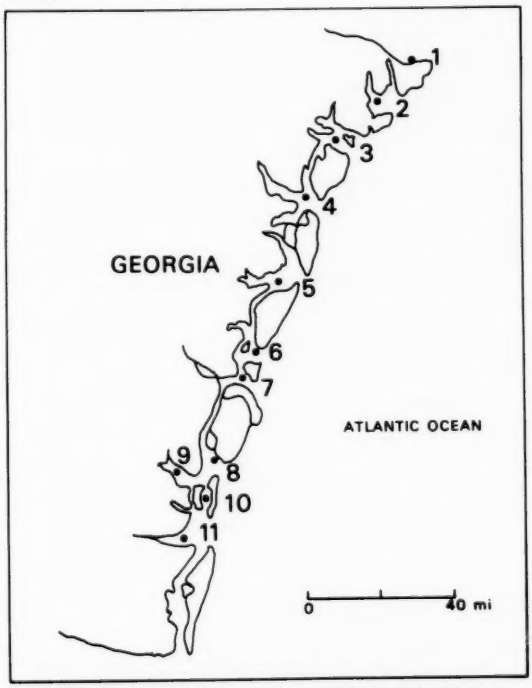

FIGURE E-1.—*Diagram of coastal Georgia showing approximate location of monitoring stations*

1. Lazeretta Creek—Savannah River Basin
2. Wilmington River—Savannah River Basin
3. Ogeechee River—Ogeechee River Basin
4. St. Catherine Sound—Ogeechee River Basin
5. Sapelo Sound—Ogeechee River Basin
6. Doboy Sound—Ogeechee River Basin
7. Egg Island—Altamaha River Basin
8. St. Simons Sound—Satilla River Basin
9. Terry Creek—Satilla River Basin
10. Jekyll Island—Satilla River Basin
11. Satilla River—Satilla River Basin

TABLE E-1—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1967-72—Georgia*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)			
				DDT	Dieldrin	Toxaphene	PCB's [2]
1	Lazeretta Creek	1967-72	64	30 (96)	58 (230)		
2	Wilmington River	1967-72	65	21 (86)	27 (90)		
3	Ogeechee River	1967-72	65	13 (50)	15 (26)		1
4	St. Catherine Sound	1967-72	65	7 (15)	2 (T)		1
5	Sapelo Sound	1967-72	65	12 (50)	6 (12)		2
6	Doboy Sound	1967-72	64	7 (27)	8 (14)		1
7	Egg Island	1967-72	65	3 (52)	22 (23)		
8	St. Simons Sound	1967-72	65	[3]	3 (T)	64 (7,500)	2
9	Terry Creek	1967-70	16	[3]		16 (54,000)	
10	Jekyll Island	1967-72	62	[3]		37 (3,500)	8
11	Satilla River	1967-72	64	3 (15)		8 (1,000)	1
	Occasional stations (2)	1968-69	4	[3]		3 (13,000)	
Total number of samples			664				
Percent of samples positive for indicated compound				15	21	19	2

NOTE: T = >5 but <10 ppb.
[1] Each sample represents 15 or more mature mollusks.
[2] Present but not quantified.
[3] Presence of toxaphene prevented quantification of DDT and its metabolites.

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
RESIDUES IN PPB (μg/kg) [Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]													
STATION 1.—LAZERETTA CREEK—64 SAMPLES [1]													
1967	DDE		14	13	21	T	T	53	—	—	—	—	12
	TDE		17	14	29	13	11	25	14	—	—	—	16
	DDT		—	—	T	—	T	18	11	—	—	—	T
	Dieldrin		98	65	56	32	30	30	33	18	42	33	46
1968	DDE	—	13	12	17	—	—	15	—	—		—	T
	TDE	—	16	12	23	—	—	23	—	—		—	T
	DDT	—	—	—	T	—	—	28	—	—		—	—
	Dieldrin	22	42	37	46	—	20	39	22	18		42	56
1969	DDE	—	—	—	—	—	T	—	—	—	—	—	T
	TDE	—	—	—	—	—	13	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	39	23	47	51	16	35	28	23	20	180	230	20
1970	DDE	T	13	—	T	T	—	—	T	—	23	—	—
	TDE	—	—	—	T	T	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	30	31	40	32	17	23	80	T	—	—	T	T

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		RESIDUES IN PPB (μg/kg)											
		[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]											
		STATION 1.—LAZERETTA CREEK—64 SAMPLES [1]—Continued											
1971	DDE	—	—	20	—	—	—	—	—	—	T	T	—
	TDE	—	—	—	—	—	—	—	—	—	T	T	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	19	19	T	17	13	10	—	T	T	—	—	13
1972	DDE	T	T	23	18	T	T						
	TDE	—	T	14	12	T	T						
	DDT	—	—	T	T	—	T						
	Dieldrin	15	13	T	T	22	T						
		STATION 2.—WILMINGTON RIVER—65 SAMPLES [1]											
1967	DDE		T	T	T	—	—	T	12	—	—	—	—
	TDE		T	T	T	—	—	T	—	—	—	—	—
	DDT		—	—	—	—	—	—	—	—	—	—	—
	Dieldrin		17	19	22	—	—	—	—	—	—	—	—
1968	DDE	—	—	T	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	10	21	12	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	10	—	—	—	—	—	—	90	T
1970	DDE	—	11	—	T	—	—	—	T	86	—	—	—
	TDE	—	—	—	T	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	T	T	10	25	—	T	—	—	—	—	—	T
1971	DDE	—	—	10	—	—	—	—	—	—	T	T	T
	TDE	—	—	—	—	—	—	—	—	—	T	T	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	T	12	12	T	T	—	—	—	—	—	T	T
1972	DDE	T	12	15	12	T	T						
	TDE	—	13	T	11	T	T						
	DDT	—	—	—	—	T	T						
	Dieldrin	10	17	15	—	T	T						

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		RESIDUES IN PPB (μg/kg)											
		[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]											
		STATION 3.—OGEECHEE RIVER—65 SAMPLES [1]											
1967	DDE		T	T	T	—	—	—	T	—	—	—	T
	TDE		T	10	—	—	—	—	—	—	—	—	T
	DDT		—	—	—	—	—	—	—	—	—	—	T
	Dieldrin		13	26	10	—	—	—	—	—	—	—	—
1968	DDE	—	—	13	T	—	—	—	—	—	—	—	—
	TDE	—	—	13	11	—	—	—	—	—	—	—	—
	DDT	—	—	24	—	—	—	—	—	—	—	—	—
	Dieldrin	—	18	16	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	T	—	—	—	16	—	—	—	T
	PCB's	—	—	—	—	—	—	—	—	—	—	—	[2]
1970	DDE	—	10	—	—	—	—	—	T	12	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	T	T	T	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	T	T	T	—	—	11	—	—	—	—	—
1972	DDE	—	—	T	—	T	T						
	TDE	—	—	—	—	—	T						
	DDT	—	—	—	—	—	—						
		STATION 4.—ST. CATHERINE SOUND—65 SAMPLES [1]											
1967	DDE		T	T	T	—	—	—	—	—	—	—	—
	TDE		T	—	—	—	—	—	—	—	—	—	—
	DDT		T	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	T	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	PCB's	—	—	—	—	—	—	—	—	—	—	—	[2]

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		RESIDUES IN PPB (μg/kg)											
		[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]											
		STATION 4.—ST. CATHERINE SOUND—65 SAMPLES [1]—Continued											
1970	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	T	—	T	—	—	—	—	—	—	—	—
1972	DDE	—	—	T	—	T	T						
	TDE	—	—	—	—	—	T						
	DDT	—	—	—	—	—	—						
		STATION 5.—SAPELO SOUND—65 SAMPLES [1]											
1967	DDE		T	T	T	—	T	T	—	—	—	—	T
	TDE		T	—	T	—	T	22	—	—	—	—	T
	DDT		T	—	—	—	T	23	—	—	—	—	—
	Dieldrin		12	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	T	—	—	—	—	—	—	—	—	—
	TDE	—	—	13	—	—	—	—	—	—	—	—	—
	DDT	—	—	19	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	T	—	—	—	—	—	—	—	—
	PCB's	—	—	—	—	—	—	—	—	—	—	(2)	(2)
1970	DDE	—	11	—	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	T	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	T	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	T	T	T	—	—	—	—	—	—	—	—
1972	DDE	—	—	T	—	T	T						
	TDE	—	—	—	—	—	T						
	DDT	—	—	—	—	T	—						

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

YEAR	COMPOUND	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
		RESIDUES IN PPB (μg/kg)											
		[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]											
		STATION 6.—DOBOY SOUND—64 SAMPLES [1]											
1967	DDE		T	T	—	—	—	T	—	—	—	—	—
	TDE		—	T	—	—	—	11	—	—	—	—	—
	DDT		—	—	—	—	—	11	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	14	14	13	—	—	—	—	—	—	—	—
	PCB's	—	—	—	—	—	—	—	—	—	—	(2)	—
1970	DDE	—	10	—	—		—	—	—	—	—	—	—
	TDE	—	—	—	—		—	—	—	—	—	—	—
	DDT	—	—	—	—		—	—	—	—	—	—	—
	Dieldrin	T	—	—	—		—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	T	T	T	—	T	—	—	—	—	—	—	—
1972	DDE	—	—	T	T	T	—						
	TDE	—	—	T	—	—	—						
	DDT	—	—	—	—	—	—						
		STATION 7.—EGG ISLAND—65 SAMPLES [1]											
1967	DDE		—	—	—	—	—	15	—	—	—	—	—
	TDE		—	—	—	—	—	19	—	—	—	—	—
	DDT		—	—	—	—	—	18	—	—	—	—	—
	Dieldrin		—	—	—	—	—	—	—	—	—	—	20
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	13	15	23	14	—	—	—	—	—	—	—	21
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	16	—	15	15	—	—	—	—	—	—	—	T

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		RESIDUES IN PPB (μg/kg)											
		[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]											
		STATION 7.—EGG ISLAND—65 SAMPLES [1]—Continued											
1970	DDE	—	16	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	T	T	T	—	T	—	—	—	—	T	T	T
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	11	T	T	T	—	—	—	—	—	—	—	—
1972	DDE	—	—	T	—	—	—						
	TDE	—	—	—	—	—	—						
	DDT	—	—	—	—	—	—						
	Dieldrin	—	T	—	—	—	—						
		RESIDUES IN PPM (mg/kg)											
		[Blank = no sample collected; — = no residue detected above 0.1 ppm or no residue detected (PCB's); T = >0.1 but <0.25 ppm]											
		STATION 8.—ST. SIMONS ISLAND—65 SAMPLES [1,3,5]											
1967	Toxaphene		[4]	2.5	1.5	1.5	1.0	1.0	1.1	0.8	0.7	2.0	2.0
1968	Toxaphene	0.8	5.0	6.0	4.3	1.6	2.0	2.0	0.6	T	—	5.4	2.8
1969	Toxaphene	2.0	1.2	2.5	7.5	5.0	1.5	1.0	1.0	1.5	1.6	1.6	1.8
1970	Toxaphene	3.8	3.8	7.2	3.3	1.8	1.1	<1.0	0.8	T	0.6	0.7	1.6
	PCB's	—	—	—	—	—	—	[2]	—	—	—	—	—
1971	Toxaphene	1.3	0.7	1.1	1.6	0.7	0.1	0.6	T	T	0.6	T	0.6
	PCB's	—	—	—	—	[2]	—	—	—	—	—	—	—
1972	Toxaphene	0.6	1.0	1.1	1.0	0.8	0.6						
		RESIDUES IN PPM (mg/kg)											
		[Blank = no sample collected; — = no residues detected above 0.1 ppm; T = >0.1 but <0.25 ppm]											
		STATION 9.—TERRY CREEK—16 SAMPLES [1]											
1967	Toxaphene				12.0			4.7				18.0	13.0
1968	Toxaphene		23.0	6.0	54.0		5.0				6.3	12.0	
1969	Toxaphene	9.0				12.0	17.0		8.0				
1970	Toxaphene				6.2	8.2							

TABLE E-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Georgia*—Continued

Year	Compound	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		RESIDUES IN PPM (mg/kg) [Blank = no sample collected; — = no residue detected above 0.1 ppm; T = >0.1 but <0.26 ppm]											
		STATION 10.—JEKYLL ISLAND—62 SAMPLES [1,6]											
1967	Toxaphene		—	T	0.5	0.4	0.4	—	—	—		1.0	
1968	Toxaphene	0.7	2.1	0.7	0.7	0.5	T	0.4	—	—	—	—	—
	PCB's	—	—	—	—	—	—	—	—	—	—	—	—
1969	Toxaphene	1.0	1.0	1.0	1.0		—	—	—	3.5	T	—	0.7
	PCB's	—	—	—	—		—	—	[2]	—	[2]	—	—
1970	Toxaphene	0.8	—	T	T	—	—	—	—	—	—	—	0.6
	PCB's	—	[2]	[2]	[2]	[2]	—	—	—	—	—	—	—
1971	Toxaphene	0.5	T	0.6	0.8	T	T	—	—	—	0.5	T	T
	PCB's	—	[2]	—	—	[2]	—	—	—	—	—	—	—
1972	Toxaphene	0.3	T	1.0	0.6	T	—						
		RESIDUES IN PPM (mg/kg) [Blank = no sample collected; — = no residue of DDT detected above 0.005 ppm or no residue detected above 0.1 ppm (toxaphene and PCB's); t = >0.1 but <0.25 ppm; T = >0.005 but <0.010 ppm]											
		STATION 11.—SATILLA RIVER—64 SAMPLES [1]											
1967	DDE		—	—	—	—	—	—	—	—	—	—	—
	TDE		—	—	—	—	—	—	—	—	—	—	—
	DDT		—	—	—	—	—	—	—	—	—	—	—
	Toxaphene		—	t	t	t	t	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	
	TDE	—	—	—	—	—	—	—	—	—	—	—	
	DDT	—	—	—	—	—	—	—	—	—	—	—	
	Toxaphene	1.0	0.5	0.7	t	—	—	—	—	—	—	—	
1969	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1970	DDE	—	15	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	T	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	PCB's	—	[2]	—	—	—	—	—	—	—	—	—	—
1972	DDE	—	—	—	—	—	—						
	TDE	—	—	T	—	—	—						
	DDT	—	—	—	—	—	—						

[1] Each sample represents 15 or more mature mollusks.
[2] Aroclor 1254® present but not quantified.
[3] Presence of toxaphene prevented quantification of DDT and its metabolites in these samples.
[4] Toxaphene present but not quantified.
[5] One sample each in April 1969, April 1970, and February 1972 contained a trace of dieldrin.
[6] DDT and its metabolites not detected in any samples.

SECTION F.—MAINE

The monthly monitoring of Maine estuaries for persistent synthetic residues was initiated in December 1965 and continued until November 1970. There were 10 principal stations; about 40 other sites were sampled occasionally. Samples were analyzed at the Gulf Breeze Laboratory until June 1969 and, thereafter, at the Fisheries Research Station, Maine Department of Sea and Shore Fisheries.

The soft clam (*Mya arenaria*) and the blue mussel (*Mytilus edulis*) were the principal mollusks monitored and, on occasion, both eastern oysters (*Crassostrea virginica*) and horse mussels (*Modiolus modiolus*) were collected at the same sites. In the laboratory, the uptake of DDT was greater in the soft clam than in other species tested as was the flushing rate, and 90% of DDT residues was lost within 7 days after the toxicant was removed. This may explain why in simultaneous collections of two or more species of mollusks, DDT residues in soft clams examined at 30-day intervals were usually lower than those in the oyster or horse mussel. A summary of data on organochlorine residues in the monitored species, is presented in Table F-1, and the distribution of residues in these species for each sampling station by date of collection in Table F-2.

The Maine samples are characterized by the low incidence (18%) of detectable DDT residues as compared to most other monitored areas, despite the fact that substantial amounts of DDT are reported to have been used agriculturally in some watersheds in Maine. The maximum magnitude of DDT residues detected was, however, larger than that found in seven other States. Analysis of occasional collections of fish and invertebrates other than mollusks revealed DDT residues larger than those in mollusks. Presumably organochlorine pollution in Maine estuaries was usually too low and too transitory to be detected except in animals that retain residues for a long period of time.

Despite the generally low incidence of DDT residues at most stations, there was sufficient continuity in detectable DDT residues at Station 10 on the Piscataqua River to show a gradual decline from an average of about 28 ppb in 1966 to an undetectable level in 1970. A similar trend is clearly shown in samples collected at Station 7, Small Point.

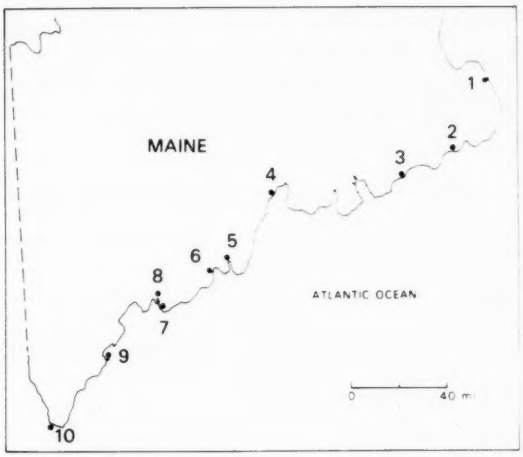

FIGURE F-1.—*Diagram of coastal Maine showing approximate location of monitoring stations*

1. Mill Cove—St. Croix River
2. Machiasport—Machias River
3. Millbridge—Narraguagus River
4. Fort Point—Penobscot River
5. Thomaston—St. George River
6. Medomak—Medomak River
7. Small Point—Kennebec-Androscoggin River
8. Phippsburg—Kennebec-Androscoggin River
9. Biddeford Pool—Saco River
10. Eliot—Piscataqua River

TABLE F-1—*Summary of data on organochlorine residues in the monitored species, 1965-70—Maine*

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
					DDT	Dieldrin
1	Mill Cove	1965-66	*M. arenaria*	12		
2	Machiasport	1965-70	*M. arenaria*	52	2 (15)	
3	Millbridge	1966-70	*M. arenaria*	37	1 (12)	
4	Fort Point	1965-70	*M. arenaria*	42	1 (15)	
5	Thomaston	1965-70	*M. arenaria*	42	1 (80)	1 (11)
6	Medomak	1967-70	*M. arenaria*	23	2 (11)	
7	Small Point	1968-70	*M. edulis*	18	12 (359)	

TABLE F-1.—*Summary of data on organochlorine residues in the monitored species, 1965-70—Maine*—Continued

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µg/kg)	
					DDT	Dieldrin
8	Phippsburg	1965-69	*M. arenaria*	39	7 (24)	
9	Biddeford Pool	1968-70	*M. edulis*	24	7 (64)	
10	Eliot	1966-70	*M. arenaria*	45	22 (67)	9 (38)
11	Occasional stations (40)	1965-69	Mixed	62	16 (93)	4 (18)
Total number of samples				396		
Percent of samples positive for indicated compound					18	4

[1] Each sample represents 15 or more mature mollusks.

TABLE F-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Maine*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb.]

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—MILL COVE—*M. ARENARIA*—12 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 2.—MACHIASPORT—*M. ARENARIA*—52 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—	—	T	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—		—	—	—	—	—	—	—	—	—	—
	TDE	—		—	—	—	—	—	—	—	—	—	—
	DDT	—		—	—	—	—	—	—	—	—	—	—
1968	DDE	—			—	—	—	—	—	—	T	—	—
	TDE	—			—	—	—	—	—	—	T	—	—
	DDT	—			—	—	—	—	—	—	T	—	—
1969	DDE		—	—	—	—	—	—	—	—	—	—	—
	TDE		—	—	—	—	—	—	—	—	—	—	—
	DDT		—	—	—	—	—	—	—	—	—	—	—

TABLE F-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Maine*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—MACHIASPORT—*M. ARENARIA*—52 SAMPLES [1]—Continued													
1970	DDE				—		—	—	—	—	—	—	
	TDE				—		—	—	—	—	—	—	
	DDT				—		—	—	—	—	—	—	
STATION 3.—MILLBRIDGE—*M. ARENARIA*—37 SAMPLES [1]													
1966	DDE												—
	TDE												—
	DDT												—
1967	DDE				—	—	—	—	—	—	—	—	—
	TDE				—	—	—	—	—	—	—	—	—
	DDT				—	—	—	—	—	—	—	—	—
1968	DDE			—	—	—	—	—	—	—	—	—	—
	TDE			—	—	—	—	—	—	—	—	—	—
	DDT			—	—	—	—	—	—	—	—	—	—
1969	DDE		—	—	—	—	—	—	—	—	—	—	—
	TDE		—	—	—	—	—	—	—	—	—	—	—
	DDT		—	—	—	—	—	—	—	—	—	—	—
1970	DDE						—	—	—	12	—	—	
	TDE						—	—	—	—	—	—	
	DDT						—	—	—	—	—	—	
STATION 4.—FORT POINT—*M. ARENARIA*—42 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—	—	—	—	—	—		—	—	
	TDE	—	—	—	—	—	—	—	—		—	—	
	DDT	—	—	—	—	—	—	—	—		—	—	
1967	DDE			—	—	—	—	—	—	—	—	—	—
	TDE			—	—	—	—	—	—	—	—	—	—
	DDT			—	—	—	—	—	—	—	—	—	—
1968	DDE			—	—	—	—	—		—	—	—	—
	TDE			—	—	—	—	—		—	—	—	—
	DDT			—	—	—	—	—		—	—	—	15
1969	DDE	—	—	—	—	—	—	—	—	—			—
	TDE	—	—	—	—	—	—	—	—	—			—
	DDT	—	—	—	—	—	—	—	—	—			—

TABLE F-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Maine*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—FORT POINT—*M. ARENARIA*—42 SAMPLES [1]—Continued													
1970	DDE	—	—										
	TDE	—	—										
	DDT	—	—										
STATION 5.—THOMASTON—*M. ARENARIA*, UNLESS OTHERWISE INDICATED—42 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE		—	—	—	—	—	—	—		21	—	
	TDE		—	—	—	—	—	—	—		35	—	
	DDT		—	—	—	—	—	—	—		24	—	
	Dieldrin		—	—	—	11	—	—	—		—	—	
1967	DDE	—		—	—	—	—	—	—	—	—	—	—
	TDE	—		—	—	—	—	—	—	—	—	—	—
	DDT	—		—	—	—	—	—	—	—	—	—	—
1968	DDE			—	—	—	—		—	—	—	—	
	TDE			—	—	—	—		—	—	—	—	
	DDT			—	—	—	—		—	—	—	—	
1969	DDE	[2] —			—	—	—	—	—			—	
	TDE	—			—	—	—	—	—			—	
	DDT	—			—	—	—	—	—			—	
1970	DDE	—	—			—		—		—	—		
	TDE	—	—			—		—		—	—		
	DDT	—	—			—		—		—	—		
STATION 6—MEDOMAK—*M. ARENARIA*—23 SAMPLES [1]													
1967	DDE	—			—	—	—	—	—		—	—	—
	TDE	—			—	—	—	—	—		—	—	—
	DDT	—			11	—	T	—	—		—	—	—
1968	DDE				—	—				—	—	—	
	TDE				—	—				—	—	—	
	DDT				—	—				—	—	—	
1969	DDE				—	—	—		—			—	
	TDE				—	—	—		—			—	
	DDT				—	—	—		—			—	
1970	DDE				—			—		—	—		
	TDE				—			—		—	—		
	DDT				—			—		—	—		

TABLE F-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Maine*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—SMALL POINT—*M. EDULIS*—18 SAMPLES [1]													
1968	DDE							35	21	17	12	25	19
	TDE							44	25	20	14	27	18
	DDT							280	77	68	18	26	26
1969	DDE		11		T	T	T	12	—	—	—		—
	TDE		14		T	T	T	21	—	—	—		—
	DDT		18		15	13	T	13	49	—	—		—
1970	DDE	—	—		—								
	TDE	—	—		—								
	DDT	—	—		—								
STATION 8.—PHIPPSBURG—*M. ARENARIA*—39 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—	—	—	—	—	—			—	—
	TDE	—	—	—	—	—	—	—	—			—	—
	DDT	—	—	—	—	—	—	—	—			—	—
1967	DDE	—	—	—	T	—	—	—	—		—	—	—
	TDE	—	—	—	—	—	—	—	—		—	—	—
	DDT	—	—	—	11	11	T	—	—		—	—	—
1968	DDE		—	—	—	—	T	—	—	—	—	—	—
	TDE		—	—	—	—	—	—	—	—	—	—	—
	DDT		—	—	—	T	19	—	—	—	—	T	11
1969	DDE	—		—	—			—	—		—		
	TDE	—		—	—			—	—		—		
	DDT	—		—	—			—	—		—		
STATION 9.—BIDDEFORD POOL—*M. EDULIS*—24 SAMPLES [1]													
1968	DDE			—		—	T	—	T	T	T	T	
	TDE			—		—	T	—	T	T	T	T	
	DDT			—		—	21	—	54	22	15	13	
1969	DDE			T	—	T		—	—	—		—	—
	TDE			T	—	—		—	—	—		—	—
	DDT			21	—	12		—	—	—		—	—
1970	DDE	—			—	—		—	—	—	—	—	
	TDE	—			—	—		—	—	—	—	—	
	DDT	—			—	—		—	—	—	—	—	

TABLE F-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—Maine*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 10.—ELIOT—*M. ARENARIA*, UNLESS OTHERWISE INDICATED—45 SAMPLES [1]													
1966	DDE	T	—	12	14	13	13	T	—	T	T	T	—
	TDE	T	—	16	21	19	21	11	—	T	11	T	—
	DDT	21	T	32	32	23	16	T	—	T	T	T	—
	Dieldrin	32	—	38	—	27	23	—	—	—	—	—	T
1967	DDE	—		—	T	T	—	—	—	T	T	—	T
	TDE	—		—	11	14	T	—	—	15	T	—	T
	DDT	—		—	20	18	30	—	—	T	22	—	15
	Dieldrin	—		16	Lost	10	T	—	—	—	—	—	—
1968	DDE			—	T		—	—	T	—	—	—	
	TDE			T	12		—	—	12	—	—	—	
	DDT			18	15		—	—	T	—	—	—	
	Dieldrin			10	—		—	—	—	—	—	—	
1969	DDE			[3] 11	[3] 12	T		—	—	—			—
	TDE			23	22	T		—	—	—			—
	DDT			18	14	T		—	—	—			—
1970	DDE				—	—	—		—	—	—	—	
	TDE				—	—	—		—	—	—	—	
	DDT				—	—	—		—	—	—	—	

[1] Each sample represents 15 or more mature mollusks.
[2] *M. edulis*.
[3] *M. demissus*.

SECTION G.—MARYLAND

Eastern oysters, *Crassostrea virginica*, were collected in upper Chesapeake Bay and its tributaries at irregular intervals (usually twice yearly) from August 1966 to November 1970. The sampling was made possible because of oyster surveys being conducted for other programs. All samples from the 10 locations in Maryland were analyzed at the Gulf Breeze Laboratory. The approximate station locations are shown in Fig. G-1. A summary of data on organochlorine residues in the monitored species, *C. virginica*, is presented in Table G-1, and the distribution of residues in this species for each sampling station by date of collection in Table G-2.

Maryland was fifth among all States, in the incidence of DDT residues (81%), but the magnitude of residues in oysters was surprisingly low in view of the size of the Susquehanna River watershed and the extent of its agricultural development. More selective monitoring might show that the major pesticide burden of the river is precipitated with silt in the headwaters of the Bay and does not enter the trophic web of the estuarine system extensively. DDT residues detected at monitoring stations probably reflected pollution primarily in the adjacent and usually small drainage basins.

Despite the small number of samples, the decline in average DDT residues from 26 ppb in 1966 to 10 ppb in 1970 together with a more than 150% increase in samples containing less than 11 ppb suggests a real change in average pollution levels.

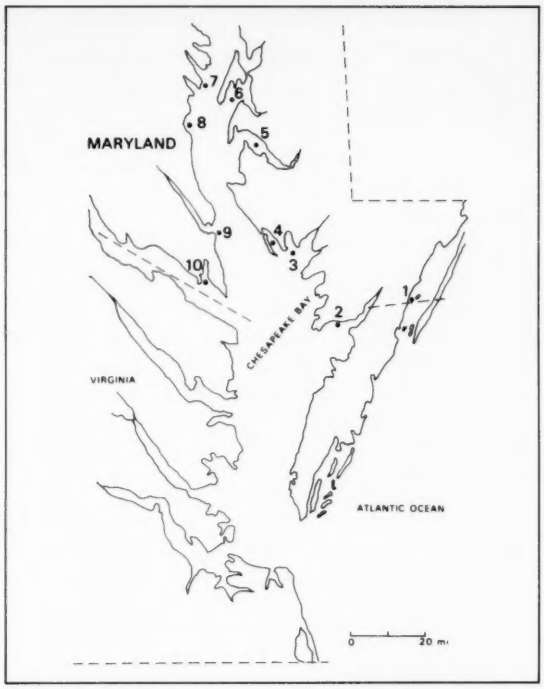

FIGURE G-1.—*Diagram of coastal Maryland showing approximate location of monitoring stations*

1. Franklin City—Chincoteague Bay
2. Pocomoke Sound
3. Tangier Sound
4. Honga River
5. Choptank River
6. Eastern Bay
7. Tollys Bar—Chesapeake Bay
8. Herring Bay—Chesapeake Bay
9. Cedar Point—Chesapeake Bay
10. St. Marys River

TABLE G-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1966-70—Maryland*

Station Number	Location	Monitoring Period	Number of Samples[1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
				DDT	Dieldrin
1	Franklin City	1966-70	8	8 (43)	
2	Pocomoke Sound	1966-69	6	5 (47)	
3	Tangier Sound	1966-70	10	5 (48)	
4	Honga River	1966-70	10	8 (43)	
5	Choptank River	1966-70	8	4 (30)	
6	Eastern Bay	1966-70	10	8 (70)	
7	Tollys Bar	1967-70	8	8 (44)	7 (22)
8	Herring Bay	1966-70	10	9 (46)	4 (18)
9	Cedar Point	1966-70	10	9 (70)	
10	St. Marys River	1966-70	8	7 (33)	
Total number of samples			88		
Percent of samples positive for indicated compound				81	13

[1] Each sample represents 15 or more mature mollusks.

TABLE G-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Maryland*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—FRANKLIN CITY—8 SAMPLES [1]													
1966	DDE								10			T	
	TDE								14			—	
	DDT								T			—	
1967	DDE			11				10					
	TDE			—				—					
	DDT			—				13					
1968	DDE				26			T				T	
	TDE				17			T				—	
	DDT				—			16				T	
1969		No Samples Collected											
1970	DDE				14								
	TDE				—								
	DDT				—								
STATION 2.—POCOMOKE SOUND—6 SAMPLES [1]													
1966	DDE								—			T	
	TDE								17			T	
	DDT								T			—	
1967	DDE			T					T				
	TDE			T					T				
	DDT			—					T				
1968	DDE							11					
	TDE							12					
	DDT							24					
1969	DDE			—									
	TDE			—									
	DDT			—									
STATION 3.—TANGIER SOUND—10 SAMPLES [1]													
1966	DDE								13			T	
	TDE								24			T	
	DDT								11			—	
1967	DDE		—					T					
	TDE		—					—					
	DDT		—					10					

TABLE G-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Maryland*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 3.—TANGIER SOUND—10 SAMPLES[1]—Continued													
1968	DDE				T			17			—		
	TDE				T			10			—		
	DDT				—			—			—		
1969	DDE			—									
	TDE			—									
	DDT			—									
1970	DDE				—							—	
	TDE				—							—	
	DDT				—							—	
STATION 4.—HONGA RIVER—10 SAMPLES[1]													
1966	DDE								T			12	
	TDE								12			20	
	DDT								11			11	
1967	DDE		T					T					
	TDE		12					T					
	DDT		—					T					
1968	DDE				T			T			T		
	TDE				—			T			—		
	DDT				—			28			10		
1969	DDE			—									
	TDE			—									
	DDT			—									
1970	DDE				—							T	
	TDE				—							10	
	DDT				—							—	
STATION 5.—CHOPTANK RIVER—8 SAMPLES[1]													
1966	DDE								T			T	
	TDE								11			13	
	DDT								—			12	
1967	DDE		T					T					
	TDE		11					T					
	DDT		—					—					
1968	DDE										—		
	TDE										—		
	DDT										—		

TABLE G-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Maryland*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—CHOPTANK RIVER—8 SAMPLES [1]—Continued													
1969	DDE			—									
	TDE			—									
	DDT			—									
1970	DDE				—							—	
	TDE				—							—	
	DDT				—							—	
STATION 6.—EASTERN BAY—10 SAMPLES [1]													
1966	DDE								—				14
	TDE								—				17
	DDT								—				—
1967	DDE		11					T					
	TDE		15					11					
	DDT		—					T					
1968	DDE				—			11				11	
	TDE				—			11				—	
	DDT				—			48				16	
1969	DDE			10									
	TDE			T									
	DDT			—									
1970	DDE				11							10	
	TDE				T							10	
	DDT				—							—	
STATION 7.—TOLLYS BAR—8 SAMPLES [1]													
1967	DDE		18					13					
	TDE		19					17					
	DDT		T					11					
	Dieldrin		13					13					
1968	DDE				14			12			15		
	TDE				11			14			13		
	DDT				—			T			16		
	Dieldrin				15			—			11		
1969	DDE			15									
	TDE			14									
	DDT			—									
	Dieldrin			16									

TABLE G-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Maryland*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—TOLLYS BAR—8 SAMPLES [1]—Continued													
1970	DDE			16								T	
	TDE			17								10	
	DDT			—								—	
	Dieldrin			22								15	
STATION 8.—HERRING BAY—10 SAMPLES [1]													
1966	DDE								10			T	
	TDE								15			—	
	DDT								T			—	
1967	DDE		12					10					
	TDE		11					17					
	DDT		—					T					
	Dieldrin		—					13					
1968	DDE				T			12			12		
	TDE				T			14			11		
	DDT				—			20			11		
1969	DDE			10									
	TDE			11									
	DDT			—									
	Dieldrin			13									
1970	DDE				14								—
	TDE				16								—
	DDT				—								—
	Dieldrin				18								12
STATION 9.—CEDAR POINT—10 SAMPLES [1]													
1966	DDE							18				20	
	TDE							27				24	
	DDT							25				15	
1967	DDE		22					15					
	TDE		20					16					
	DDT		T					13					
1968	DDE				T			21			T		
	TDE				—			13			T		
	DDT				—			16			24		
1969	DDE			T	11								
	TDE			T	12								
	DDT			—	—								

TABLE G-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Maryland*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 9.—CEDAR POINT—10 SAMPLES[1]—Continued													
1970	DDE											—	
	TDE											—	
	DDT											—	
STATION 10.—ST. MARYS RIVER—8 SAMPLES[1]													
1966	DDE							—				12	
	TDE							—				16	
	DDT							—				T	
1967	DDE		15					T					
	TDE		17					T					
	DDT		—					T					
1968	DDE				T			11				T	
	TDE				—			11				—	
	DDT				—			11				12	
1969		No Samples Collected											
1970	DDE			15									
	TDE			11									
	DDT			—									

[1] Each sample represents 15 or more mature mollusks.

SECTION H.—MISSISSIPPI

Mississippi Sound and tributaries were monitored for organochlorine residues in eastern oysters, *C. virginica*, during the period August 1965 - June 1972. All samples from the eight sampling stations were analyzed at the Gulf Breeze Laboratory. Approximate station locations are shown in Fig. H-1. A summary of data on organochlorine residues in the monitored species, *C. virginica*, is presented in Table H-1, and the distribution of residues in this species for each sampling station by date of collection in Table H-2.

Only four States had a lower incidence of DDT residues in oysters, and the maximum residue detected in Mississippi (135 ppb) was lower than that in 12 of the other 14 States. Maximum DDT residues appeared to be more directly related to runoff from urban and industrialized centers rather than from agricultural areas.

In 1971, there was a more than 70% increase in the number of DDT residues of less than 10 ppb as compared to earlier years. This trend was reversed in the first 6 months of 1972 when 44% of the residues were more than 10 ppb as compared to only 25% in 1971.

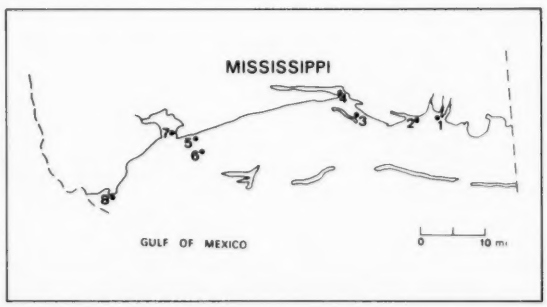

FIGURE H-1.—*Diagram of coastal Mississippi showing approximate location of monitoring stations*

1. Pascagoula—Pascagoula River
2. Graveline—Graveline Bay
3. Deer Island—Biloxi Bay
4. Biloxi Bay—Biloxi Bay
5. Pass Christian (Inshore)—Mississippi Sound
6. Pass Christian (Offshore)—Mississippi Sound
7. Bay St. Louis—St. Louis Bay
8. St. Joseph Point—Mississippi Sound

TABLE H-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-72—Mississippi*

Station Number	Location	Monitoring Period	Number of Samples[1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
				DDT	Dieldrin
1	Pascagoula	1965-72	78	47 (74)	
2	Graveline	1965-72	79	56 (99)	
3	Deer Island	1965-69	49	33 (105)	
4	Biloxi Bay	1965-72	78	71 (135)	8 (19)
5	Pass Christian (Inshore)	1965-66	13	7 (53)	
6	Pass Christian (Offshore)	1965-72	78	29 (42)	3 (16)
7	Bay St. Louis	1966-72	66	31 (124)	7 (20)
8	St. Joseph Point	1969-72	29	11 (69)	1 (18)
Total number of samples			470		
Percent of samples positive for indicated compound				61	4

[1] Each sample represents 15 or more mature mollusks.

TABLE H-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Mississippi*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—PASCAGOULA—78 SAMPLES[1]													
1965	DDE								T	T	T	14	—
	TDE								T	—	T	55	—
	DDT								T	—	—	T	—
1966	DDE	T	17		13	19	—	T	T	—	—	T	11
	TDE	T	41		10	19	—	T	—	—	—	—	12
	DDT	—	—		—	—	—	—	—	—	—	—	—
1967	DDE	13	12	11	14	T	—	—	—	T	T	T	—
	TDE	14	47	T	13	T	—	—	—	T	—	—	—
	DDT	T	10	—	—	—	—	—	—	17	—	—	—
1968	DDE	T	T	T	T	10	—	—	—	—	—	—	—
	TDE	—	T	T	T	11	—	—	—	—	—	—	—
	DDT	—	T	—	—	T	—	—	—	—	—	—	—
1969	DDE	T	—	11	T	15	T	T	—		11	12	
	TDE	13	—	12	T	19	12	T	—		14	T	
	DDT	—	—	—	—	T	—	—	—		T	—	
1970	DDE	13	12	15	16	10	T	—	—	—	—	T	—
	TDE	40	12	18	14	13	64	—	—	—	—	T	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE H-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Mississippi*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—PASCAGOULA—78 SAMPLES [1]—Continued													
1971	DDE	—	—	—	—	T	—		—	—		—	T
	TDE	—	—	—	—	12	55		—	—		—	T
	DDT	—	—	—	—	—	—		—	—		—	—
1972	DDE	T	T	—	10	11	—						
	TDE	11	T	—	10	—	—						
	DDT	—	—	—	—	—	—						
STATION 2.—GRAVELINE—79 SAMPLES [1]													
1965	DDE								T	T	T	T	T
	TDE								T	T	T	—	20
	DDT								T	—	—	—	—
1966	DDE	10	T	12	29	21	22	16	12	18	T	13	13
	TDE	27	T	10	10	60	68	19	31	69	13	17	36
	DDT	T	—	—	T	T	—	—	—	—	—	—	—
1967	DDE	14	12	23	24	T	T	T	—	T	12	14	15
	TDE	11	10	66	36	T	18	T	—	12	23	18	23
	DDT	13	—	10	T	—	—	—	—	21	29	10	T
1968	DDE	15	16	13	11	16	22	10	—	—	—	—	T
	TDE	22	23	19	18	23	25	14	—	T	—	—	—
	DDT	T	12	—	T	T	T	—	—	—	—	—	—
1969	DDE	—	—	11	T	15	T	—	—		—	11	17
	TDE	—	—	14	T	15	12	—	—		—	13	20
	DDT	—	—	—	—	T	—	—	—		—	—	10
1970	DDE		—	14	14	15	10	T	—	—	—	—	—
	TDE		—	16	17	14	11	10	—	—	—	—	—
	DDT		—	10	T	—	—	T	—	—	—	—	—
1971	DDE	15	—	—	—	12	—		—	—		—	T
	TDE	17	—	—	—	23	—		—	—		—	T
	DDT	—	—	—	—	—	—		—	—		—	—
1972	DDE	T	T	—	15	T	16						
	TDE	T	T	—	—	T	—						
	DDT	—	—	—	—	—	—						
STATION 3.—DEER ISLAND—49 SAMPLES [1]													
1965	DDE								10	T	—	T	T
	TDE								21	T	—	17	17
	DDT								T	—	—	—	—

TABLE H-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Mississippi*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 3.—DEER ISLAND—49 SAMPLES [1]—Continued													
1966	DDE	14	20	15	22	27	23	17	T	—	T	—	T
	TDE	27	43	25	45	62	65	38	T	—	T	—	11
	DDT	T	16	T	12	16	—	—	—	—	—	—	—
1967	DDE	10	15	14	15	11	—	—	—	—	—	—	T
	TDE	12	T	14	11	17	—	—	—	—	—	—	T
	DDT	T	—	—	—	—	—	—	—	12	—	—	—
1968	DDE	T	11	T	12	12	—	—	—	—	—	—	—
	TDE	13	13	T	12	12	—	—	—	—	—	—	—
	DDT	—	T	—	—	—	—	—	—	—	—	—	—
1969	DDE	T	T	11	T	T	—	T	T				
	TDE	T	—	13	13	T	—	27	34				
	DDT	—	—	—	—	—	—	—	22				
STATION 4.—BILOXI BAY—78 SAMPLES [1]													
1965	DDE								14	T	—	T	T
	TDE								23	11	—	23	18
	DDT								T	—	—	—	—
1966	DDE	14	16	16	29	32	—	20	19	—	T	15	T
	TDE	43	30	33	73	87	—	47	48	—	T	27	15
	DDT	14	T	11	15	16	—	—	—	—	—	T	—
1967	DDE	16	19	23	28	15	13	T	T	—	—	T	T
	TDE	31	40	43	50	33	21	43	25	17	17	19	22
	DDT	15	23	15	20	—	T	—	—	T	T	—	—
	Dieldrin	—	—	—	13	—	—	—	—	—	—	—	—
1968	DDE	12	14	16	20	30	17	T	—	—	—	T	16
	TDE	32	30	39	34	94	61	52	25	24	T	43	49
	DDT	—	T	—	T	T	—	—	—	—	—	—	—
1969	DDE	T	18	17	14	20	17	T	—		14	14	20
	TDE	28	46	47	46	67	54	22	25		42	28	53
	DDT	—	T	T	11	T	—	—	—		18	—	12
	Dieldrin	—	—	—	—	—	—	—	—		—	16	18
1970	DDE			18	19	28	—	—	—	—	—	—	—
	TDE			60	50	78	—	77	40	—	12	12	17
	DDT			15	T	14	—	—	—	—	—	—	—
	Dieldrin			19	16	15	—	11	—	16	—	—	—
1971	DDE	T	24	16	24	T	—		22	—		—	T
	TDE	26	65	43	69	85	—		81	—		19	27
	DDT	—	—	—	—	—	—		—	—		—	—

TABLE H-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Mississippi*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—BILOXI BAY—78 SAMPLES[1]—Continued													
1972	DDE	T	10	12	18	17	T						
	TDE	20	28	35	58	63	30						
	DDT	—	—	—	—	—	—						
STATION 5.—PASS CHRISTIAN (INSHORE)—13 SAMPLES[1]													
1965	DDE								T	T	—	T	—
	TDE								T	—	—	—	—
	DDT								—	—	—	—	—
1966	DDE	T	—	—	T	11	19	—	—				
	TDE	T	—	—	T	12	34	—	—				
	DDT	—	—	—	—	11	—	—	—				
STATION 6.—PASS CHRISTIAN (OFFSHORE)—78 SAMPLES[1]													
1965	DDE								T	—	—	T	—
	TDE								T	—	—	T	—
	DDT								—	—	—	T	—
1966	DDE	T	—	—	11	14	—	—	—	—	—	—	—
	TDE	T	—	—	12	15	—	—	—	—	—	—	—
	DDT	—	—	—	T	13	—	—	—	—	—	—	—
1967	DDE	—	—	T	—	—	—	—	—	—	—	—	T
	TDE	—	—	T	—	—	—	—	—	—	—	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	T	T	T	T	T	—	—	—	—	—	—	—
	TDE	—	T	T	11	11	—	—	—	—	—	—	—
	DDT	—	T	—	—	—	—	—	—	—	—	—	—
1969	DDE		—	—	—	T	T	—	—		—	T	T
	TDE		—	—	—	T	13	—	—		—	T	T
	DDT		—	—	—	T	—	—	—		—	—	—
1970	DDE		12	13	15	11	T	—	—	—	—	—	—
	TDE		T	22	22	16	T	—	—	—	—	—	—
	DDT		—	T	—	T	—	—	—	—	—	—	—
	Dieldrin		11	16	—	—	—	—	—	15	—	—	—
1971	DDE	—	—	—	—	T	—		—	—		—	T
	TDE	—	—	—	—	14	—		—	—		—	T
	DDT	—	—	—	—	—	—		—	—		—	—
1972	DDE	T	T	12	12	T	11						
	TDE	T	T	10	16	T	—						
	DDT	—	—	—	T	—	—						

TABLE H-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Mississippi*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—BAY ST. LOUIS—66 SAMPLES [1]													
1966	DDE									—	—	—	—
	TDE									—	—	—	—
	DDT									—	—	—	—
1967	DDE	T	T	T	T	T	—	—	—	—	—	11	T
	TDE	T	T	14	T	T	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	10	—	—	—
1968	DDE	T	T	T	T	10	—	—	—	—	—	—	—
	TDE	T	T	T	T	11	—	—	—	—	—	—	—
	DDT	—	T	—	—	T	—	—	—	—	—	—	—
1969	DDE	—	T	T	—	T	T	—	—		—	T	10
	TDE	T	—	12	—	T	11	—	—		—	11	12
	DDT	—	—	—	—	T	—	—	—		—	T	11
	Dieldrin	T	14	11	T	—	—	—	—		—	—	—
1970	DDE		T	12	17	34	32	—	—	—	—	—	—
	TDE		13	15	21	76	12	—	—	—	—	—	—
	DDT		—	—	T	14	—	—	—	—	—	—	—
	Dieldrin		17	20	—	14	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—		—	—		—	T
	TDE	—	—	—	—	13	—		—	—		—	—
	DDT	—	—	—	—	—	—		—	—		—	—
1972	DDE	T	T	—	11	T	—						
	TDE	T	T	—	11	—	—						
	DDT	—	—	—	T	—	—						
STATION 8.—ST. JOSEPH POINT—29 SAMPLES [1]													
1969	DDE											—	—
	TDE											—	—
	DDT											—	—
1970	DDE		T	T	T	14	15	—	—	—	—	—	—
	TDE		—	—	—	22	54	—	—	—	—	—	—
	DDT		—	—	—	—	—	—	—	—	—	24	—
	Dieldrin		18	—	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—		—	—		—	—
	TDE	—	—	—	—	—	—		—	—		—	—
	DDT	—	—	—	—	—	—		—	—		24	—
1972	DDE	T	T	—	—	T	T						
	TDE	—	15	—	—	T	—						
	DDT	—	—	—	—	—	—						

[1] Each sample represents 15 or more mature mollusks.

SECTION I.—NEW JERSEY

Samples of eastern oysters, *Crassostrea virginica,* were collected at five principal stations in the New Jersey waters of Delaware Bay during the period June 1966 - June 1972. All samples were analyzed at the Gulf Breeze Laboratory. The approximate station locations are shown in Fig. I-1. A summary of data on organochlorine residues in the monitored species, *C. virginica,* is presented in Table I-1, and the distribution of residues in this species for each sampling station by date of collection in Table I-2.

Oyster samples collected in Delaware Bay were characterized by a 100% incidence of DDT residues and a relatively high incidence (24%) of dieldrin residues as compared to other areas monitored.

The maximum DDT residue observed, 272 ppb, is low compared to that in many other estuaries; most residues, from New Jersey were less than half this amount. The fact that DDE was the principal component of these residues suggests that the pesticide had been metabolized in other links of the trophic web before its acquisition by the oyster.

DDT residues appear to have been somewhat higher in the 1968-69 period than earlier, but the 1971 data show a clear-cut trend towards decreased residue levels.

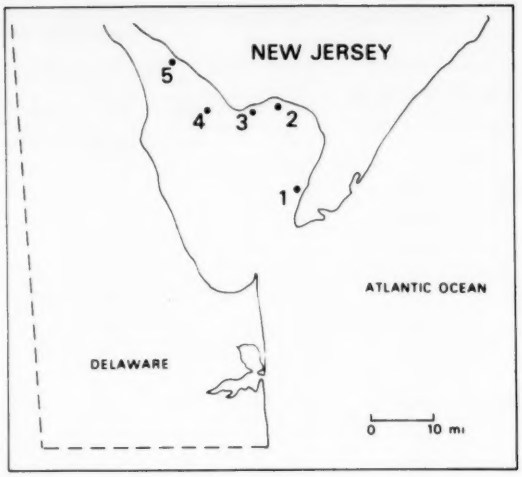

FIGURE I-1.—*Diagram of coastal New Jersey showing approximate location of monitoring stations*

1. Drum Beds—Delaware River
2. Maurice River—Delaware River
3. Dividing Creek—Delaware River
4. Lease 564/496D—Delaware River
5. Cohansey—Delaware River

TABLE I-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1966-72—New Jersey*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)		
				DDT	Dieldrin	PCB's [2]
1	Drum Beds	1966-72	49	49 (213)	3 (12)	2
2	Maurice River	1966-72	50	50 (143)	1 (T)	1
3	Dividing Creek	1966-71	7	7 (125)	1 (12)	
4	Lease 564/496D	1966-72	52	52 (278)	28 (26)	2
5	Cohansey	1966-72	49	49 (245)	16 (23)	1
	Occasional Stations (7)	1966-71	12	12 (166)	3 (29)	
Total number of samples			219			
Percent of samples positive for indicated compound				100	24	3

NOTE: T = >5 but <10 ppb.
[1] Each sample represents 15 or more mature mollusks.
[2] Present but not quantified.

TABLE I-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—New Jersey*

[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—DRUM BEDS—49 SAMPLES[1]													
1966	DDE						19		33	24		28	17
	TDE						18		38	24		26	14
	DDT						—		15	11		10	—
1967	DDE			43	39	30	31	27	18	27	37	42	
	TDE			34	28	27	30	40	25	33	46	50	
	DDT			11	T	—	—	21	16	13	22	14	
1968	DDE	43	50	55		50	110	110	55	44	75	52	
	TDE	43	43	54		57	98	83	38	35	48	44	
	DDT	10	T	T		—	T	13	13	T	11	—	
1969	DDE			49	19	48	51	73	52	63	67	56	58
	TDE			35	18	15	45	44	30	34	32	41	28
	DDT			—	—	—	—	—	T	—	T	T	T
1970	DDE			99			100	110	34	37		46	38
	TDE			42			52	47	12	15		21	16
	DDT			11			—	—	—	—		—	—
	Dieldrin			—			—	12	—	—		—	—
1971	DDE			35	59		70	38		27			53
	TDE			10	35		30	26		14			28
	DDT			—	—		—	—		—			—
1972	DDE				[2] 10		[2] 52						
	TDE				20		29						
	DDT				52		—						
	Dieldrin				T		T						
	PCB's				(3)		(3)						
STATION 2.—MAURICE RIVER—50 SAMPLES[1]													
1966	DDE						11		T	14		13	T
	TDE						15		12	15		16	T
	DDT						—		—	—		—	—
1967	DDE			12	12	13	15	12	T	18	26	19	
	TDE			T	T	19	28	23	10	30	40	31	
	DDT			17	—	—	—	T	—	13	13	—	
1968	DDE	19	24	22	21		45	37	17	20	16	24	
	TDE	27	31	32	43		68	38	21	24	17	19	
	DDT	T	—	—	—		—	16	T	10	T	T	

TABLE I-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—New Jersey*—Continued

Year	Compound	Residues in PPB (μg/kg)										
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—MAURICE RIVER—50 SAMPLES[1]—Continued													
1969	DDE		21		16	77	75	13	22	12	T	19	13
	TDE		21		15	26	68	14	23	18	11	14	T
	DDT		—		—	—	—	—	T	—	—	—	—
1970	DDE			16		24	25	32	17	13	18		13
	TDE			T		22	36	34	16	15	19		10
	DDT			—		—	—	—	—	—	—		—
1971	DDE		12		T		26	23		14	T		
	TDE		T		—		29	29		13	—		
	DDT		—		—		—	—		—	—		
1972	DDE			14			[2] 17						
	TDE			—			17						
	DDT			—			—						
	Dieldrin			—			T						
	PCB's			—			[3]						
STATION 3.—DIVIDING CREEK—7 SAMPLES[1]													
1966	DDE									T			
	TDE									13			
	DDT									—			
1967	DDE				26			41				22	
	TDE				28			66				33	
	DDT				—			18				11	
	Dieldrin				—			12				—	
1968	DDE						49						
	TDE						64						
	DDT						T						
1969	DDE				60								
	TDE				35								
	DDT				—								
1970		No Samples Collected											
1971	DDE									13			
	TDE									13			
	DDT									—			
STATION 4.—LEASE 564/496D—52 SAMPLES[1]													
1966	DDE						34		29	41		51	58
	TDE						42		39	53		53	110
	DDT						—		T	12		67	15

TABLE I-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—New Jersey*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—LEASE 564/496D—52 SAMPLES [1]—Continued													
1967	DDE			47	41	48	41	44	29	38	26	39	39
	TDE			48	39	86	81	72	47	56	41	56	56
	DDT			T	—	—	—	18	17	19	10	—	—
	Dieldrin			10	—	18	20	18	—	12	—	—	—
1968	DDE	35	38	37	23		110	77	51	69	67	57	
	TDE	50	54	60	45		140	82	46	57	57	56	
	DDT	T	T	T	—		18	23	16	T	T	T	
	Dieldrin	11	14	15	—		—	14	—	—	—	11	
1969	DDE		100		66	95	27	82	47	72	84	72	
	TDE		87		51	74	34	68	39	45	48	56	
	DDT		13		—	—	—	17	T	13	14	14	
	Dieldrin		13		12	18	21	—	—	19	13	11	
1970	DDE	130		140		180	75	35	62	95	120	42	12
	TDE	61		67		98	92	18	33	36	33	36	43
	DDT	15		16		—	—	—	—	—	—	—	—
	Dieldrin	14		16		20	26	—	—	—	—	—	12
1971	DDE		150		180		180	190		49			56
	TDE		45		87		62	78		25			18
	DDT		—		T		—	—		—			—
	Dieldrin		13		19		19	T		—			—
1972	DDE			[2] 67			[2] 46						
	TDE			42			35						
	DDT			11			—						
	Dieldrin			T			14						
	PCB's			[3]			[3]						
STATION 5.—COHANSEY—49 SAMPLES [1]													
1966	DDE						12		17		20	22	11
	TDE						24		37		35	33	23
	DDT						—		—		—	—	—
1967	DDE			29	35	41	54	24	29	17	17	32	
	TDE			45	53	19	150	59	66	39	38	59	
	DDT			T	T	22	25	10	13	—	T	—	
	Dieldrin			—	—	23	18	12	T	—	—	11	
1968	DDE	20	30	22		49	81	68	32	33	52	28	
	TDE	41	62	66		12	150	110	60	50	70	32	
	DDT	—	—	—		—	14	11	15	T	T	—	
	Dieldrin	—	12	14		13	19	12	—	—	—	—	

TABLE I-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—New Jersey*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—COHANSEY—49 SAMPLES [1]—Continued													
1969	DDE		33		59	57	36	37	29	24	42	38	
	TDE		46		43	76	49	46	45	44	48	42	
	DDT		—		—	—	—	T	T	—	—	T	
	Dieldrin		—		—	16	—	—	—	—	—	—	
1970	DDE			45	41	55		30	27	53	36	42	
	TDE			46	51	98		30	34	54	42	36	
	DDT			—	—	—		T	—	—	—	—	
	Dieldrin			—	11	21		—	—	—	—	—	
1971	DDE		52		28	38		27		21			22
	TDE		42		24	61		30		20			17
	DDT		—		—	T		—		—			—
	Dieldrin		13		—	16		—		—			—
1972	DDE			23		[2] 40							
	TDE			114		49							
	DDT			—		—							
	Dieldrin			—		T							
	PCB's			—		[3]							

[1] Each sample represents 15 or more mature mollusks.
[2] DDT values are approximate because of presence of unidentified PCB's.
[3] Present but not quantified.

SECTION J.—NEW YORK

Several different species of mollusks (*Crassotrea virginica, Modiolus domissus, Mytilus edulis, Mercenavia mercenaria,* and *Mya arenaria*) were collected at 16 principal sites in New York's coastal waters to monitor organochlorine pollution during the period March 1966 - June 1972. Samples were analyzed at the Gulf Breeze Laboratory until February 1969 and thereafter by the New York Conservation Department. Analyses of aliquots of some of the samples collected during the period October 1968 - July 1970 have been reported by the cooperating agency (*9*) and do not differ significantly from the data reported here.

Approximate station locations are shown in Fig. J-1. A summary of data on organochlorine residues in the monitored species is presented in Table J-1, and the distribution of residues in these species for each sampling station by date of collection in Table J-2.

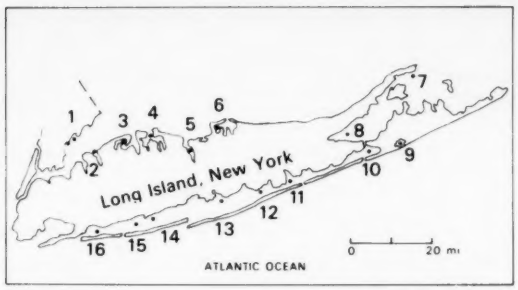

FIGURE J-1.—*Diagram of coastal New York showing approximate location of monitoring stations*

1. Mamaroneck
2. Hempstead Harbor
3. Oyster Bay Harbor
4. Huntington Bay
5. Nissequogue River
6. Conscience Bay
7. Southold—Gardiners Bay
8. Flanders Bay
9. Mecox Bay
10. Shinnecock Bay
11. Moriches Bay
12. Bellport—Great South Bay
13. Sayville—Great South Bay
14. Amityville—South Oyster Bay
15. East Bay
16. West Bay

The hard clam, *M. mercenaria,* was the principal species collected because of its ubiquity and despite its recognized inefficiency in storing organochlorine residues. This lack of sensitivity to low levels of DDT pollution is especially well documented in the analytical record of samples collected in Conscience Bay, Station 6. Hard clams were the only mollusk of four species collected there in which DDT residues were undetected. DDT pollution apparently disappeared at this station during the period July 1968 - March 1969, but this was because of the substitution of hard clams for the blue mussel as monitors.

These data emphasize the fact that in areas where hard clams did show DDT residues, there were probably significant levels of DDT in the water or food supply. This parallels the situation in Delaware, where hard clams collected in Delaware Bay (Cape Henlopen) consistently had DDT residues while residues were usually not detected in hard clams collected in inner bays. There was generally good agreement in the magnitude of residues in two or more species, other than the hard clam, collected at the same station on the same day.

The New York samples ranked fifth among the States in incidence and sixth in magnitude of DDT residues. More samples (43%) contained dieldrin residues than in any other area monitored. PCB's were present in some samples in 1972, but they were not identified or quantified.

Despite the large number of samples collected over a period of 7 years, no clearly defined trends in pollution levels can be identified. This may be the result of having used a variety of species. The overall impression is one of no significant change in DDT residue levels in mollusks.

TABLE J-1.—*Summary of data on organochlorine residues in the monitored species, 1966-72—New York*

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
					DDT	Dieldrin
1	Mamaroneck	1966-69	*M. mercenaria*	36	34 (96)	27 (29)
2	Hempstead Harbor	1966-72	*M. mercenaria*	74	70 (201)	61 (132)
3	Oyster Bay	1966-72	*M. mercenaria*	73	54 (99)	48 (86)
4	Huntington Bay	1966-72	*M. edulis*	74	72 (588)	52 (104)
5	Nissequogue River	1966-72	*M. edulis*	74	70 (138)	58 (117)
6	Conscience Bay	1966-72	*M. edulis*	73	61 (112)	52 (75)
7	Southold	1969-72	*C. virginica*	34	32 (149)	26 (78)
8	Flanders Bay	1966-72	*M. mercenaria*	69	63 (199)	15 (107)
9	Mecox Bay	1966-72	*C. virginica*	67	65 (596)	14 (22)

TABLE J-1.—*Summary if data on organochlorine residues in the monitored species, 1966-72—New York*—Continued

Station Number	Location	Monitoring Period	Principal Monitored Species	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µg/kg)	
					DDT	Dieldrin
10	Shinnecock Bay	1966-72	*M. mercenaria*	73	43 (188)	19 (46)
11	Moriches Bay	1966-72	*M. mercenaria*	71	49 (83)	13 (49)
12	Bellport Bay	1966-72	*M. mercenaria*	71	51 (132)	10 (53)
13	Sayville	1966-72	*M. mercenaria*	74	41 (107)	16 (59)
14	Amityville	1966-72	*M. mercenaria*	73	49 (64)	13 (42)
15	East Bay	1966-72	*M. mercenaria*	57	43 (98)	13 (38)
16	West Bay	1966-72	*M. mercenaria*	57	51 (111)	19 (20)
	Occasional stations (8)	1967-72	Mixed	9	9 (159)	3 (31)
Total number of samples				1,059		
Percent of samples positive for indicated compound					81	43

[1] Each sample represents 15 or more mature mollusks.

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—MAMARONECK—*M. MERCENARIA*—36 SAMPLES [1]													
1966	DDE				—	T	—	—	—	—	T	16	T
	TDE				—	T	—	13	T	12	18	49	29
	DDT				—	—	—	—	—	—	—	14	13
	Dieldrin				—	—	—	—	—	—	—	29	12
1967	DDE	T	19	12	11	11	11	T	T	T	12	T	T
	TDE	35	50	31	27	27	28	20	15	26	28	32	30
	DDT	24	27	11	11	11	15	T	T	—	T	14	T
	Dieldrin	16	21	16	16	15	15	15	14	14	13	14	15
1968	DDE	T	T	T	11	10	T	—	—	—	—	—	T
	TDE	27	25	27	30	27	26	22	20	20	18	23	19
	DDT	T	—	—	T	12	15	T	—	—	—	—	—
	Dieldrin	11	12	14	11	12	—	10	12	12	11	15	14
1969	DDE	—	10	—									
	TDE	18	24	13									
	DDT	—	—	—									
	Dieldrin	11	11	—									

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—HEMPSTEAD HARBOR—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—74 SAMPLES[1]													
1966	DDE			—	—	—	T	—	[3]24	T	11	15	13
	TDE			—	—	—	29	—	48	17	29	39	35
	DDT			—	—	—	13	—	26	—	—	17	14
	Dieldrin			—	—	—	—	—	—	—	—	17	15
1967	DDE	T	14	13	12	12	14	T	T	12	13	12	10
	TDE	17	36	35	30	33	39	23	25	29	30	32	30
	DDT	—	13	13	11	15	28	15	16	—	T	11	11
	Dieldrin	—	15	16	17	15	19	15	17	15	16	14	16
1968	DDE	11	13	13	13	10	T	—	—	—	T	—	T
	TDE	29	31	31	34	26	27	17	18	17	24	22	23
	DDT	11	—	10	10	10	—	T	—	—	—	—	—
	Dieldrin	12	16	14	15	20	16	—	—	11	50	93	66
1969	DDE	—	10	[2]15	[2]16	18	15	T	—	[3]34	[3]30	[3]23	[3]26
	TDE	12	29	33	34	18	19	22	10	93	62	57	57
	DDT	—	T	34	38	12	T	T	—	74	49	47	46
	Dieldrin	47	70	22	86	85	13	33	38	132	28	40	31
1970	DDE	[3]41	11	[3]24	[3]13	[3]12	[3]18	10	10	[3]21	[3]18	[3]18	[3]20
	TDE	71	33	51	28	33	48	22	35	71	40	48	50
	DDT	76	15	62	29	54	70	17	18	28	35	43	51
	Dieldrin	29	30	30	25	30	33	20	18	26	22	19	25
1971	DDE	[3]10	[3]13	[3]13	[3]15	[3]20		—	[3]16		[3]13	[3]22	[3]23
	TDE	22	26	33	38	27		16	37		31	46	58
	DDT	18	31	34	44	23		10	30		17	32	51
	Dieldrin	10	14	16	31	—		13	21		19	23	20
1972	DDE	[3]19	[3]17	[3]23	[3]34	[3]9	—						
	TDE	41	—	48	67	15	T						
	DDT	22	24	44	53	9	—						
	Dieldrin	19	14	19	21	—	T						
STATION 3.—OYSTER BAY HARBOR—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—73 SAMPLES[1]													
1966	DDE			—	—	—	—	—	—	—	—	T	T
	TDE			—	—	—	—	—	T	—	—	22	11
	DDT			—	—	13	—	—	—	—	—	T	—
	Dieldrin			—	—	—	—	—	—	—	—	13	11
1967	DDE	13	T	T	T	T	T	—	T	T	T	T	T
	TDE	50	15	19	14	20	22	26	17	13	T	13	15
	DDT	18	—	—	—	—	13	T	12	—	—	—	—
	Dieldrin	10	—	14	13	14	14	11	14	—	12	11	—

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 3.—OYSTER BAY HARBOR—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—73 SAMPLES [1]—Continued													
1968	DDE	T	T	—	T	T	—	—	—	—	—	—	—
	TDE	16	T	—	T	11	—	T	—	—	—	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	11	—	—	—	—	—	—	—	—	10
1969	DDE	—	T	—	[3] 11	[3] 24	—	—	—	—	[4] 27	T	—
	TDE	—	T	—	25	28	11	15	—	—	55	13	T
	DDT	—	—	—	16	32	—	T	—	—	17	—	—
	Dieldrin	T	T	12	17	24	86	16	—	17	—	15	18
1970	DDE		[4] 27	[3] 10	—	[3] 21	T	[3] 16	T		[4] 22	[4] 27	[4] 24
	TDE		52	19	—	44	16	37	18		48	55	50
	DDT		20	11	—	34	T	24	T		20	15	16
	Dieldrin		31	12	37	23	11	19	16		29	30	26
1971	DDE	[4] 19	[4] 19	[4] 22	—	[3] 13		—	—	[4] 19	[4] 23	[4] 19	[4] 23
	TDE	38	38	45	T	32		T	—	30	41	34	44
	DDT	16	T	15	—	18		—	—	13	10	17	18
	Dieldrin	18	25	27	16	18		10	—	21	20	14	17
1972	DDE	[3] 18	[3] 19	—	—	[4] 10	[3] 13						
	TDE	36	31	T	—	24	22						
	DDT	24	18	—	—	10	11						
	Dieldrin	12	15	—	10	11	19						
STATION 4.—HUNTINGTON BAY—*M. EDULIS*, UNLESS OTHERWISE INDICATED—74 SAMPLES [1]													
1966	DDE			[5] T	[5] —	[5] 32	98	[6] 53	40	[5] —	[5] —	[5] 21	[5] 29
	TDE			16	—	75	280	190	110	—	T	64	71
	DDT			—	—	81	210	60	25	—	—	17	16
	Dieldrin			—	—	—	—	18	13	—	—	12	T
1967 [5]	DDE	20	27	21	19	19	16	T	13	12	T	T	17
	TDE	88	65	54	57	54	63	50	40	39	27	22	56
	DDT	44	20	17	12	24	26	13	11	—	—	—	12
	Dieldrin	21	—	11	11	—	12	12	12	11	—	—	12
1968 [5]	DDE	T	—	12	16	15	12	—	—	—	T	T	10
	TDE	27	40	49	48	46	35	35	49	43	47	60	48
	DDT	—	T	—	T	14	—	T	—	—	—	T	11
	Dieldrin	11	11	—	12	—	—	—	—	—	—	11	T
1969	DDE	[5] —	[5] 11	[5] T	18	[5] T	[6] 30	29	[5] 15	34	24	28	30
	TDE	26	28	32	35	24	104	100	23	127	73	84	80
	DDT	—	—	—	21	21	46	50	—	47	28	55	50
	Dieldrin	T	T	T	11	14	104	26	T	18	—	23	34

TABLE I-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—HUNTINGTON BAY—*M. EDULIS*, UNLESS OTHERWISE INDICATED—74 SAMPLES [1]—Continued													
1970	DDE	38	15	23	—	20	13	21	20	19	20	24	21
	TDE	90	58	60	22	50	59	146	70	40	66	89	73
	DDT	61	40	49	12	40	40	55	29	44	28	28	29
	Dieldrin	18	16	17	38	22	21	26	21	26	22	17	17
1971	DDE	21	18	15	11	21		15	26		33	21	19
	TDE	70	57	50	37	51		63	74		14	56	60
	DDT	35	30	24	22	22		22	27		T	23	28
	Dieldrin	17	18	22	14	—		21	14		13	—	14
1972	DDE	—	14	17	15	10	14						
	TDE	T	33	40	36	20	41						
	DDT	—	20	15	18	—	15						
	Dieldrin	—	13	15	12	—	60						
STATION 5.—NISSEQUOGUE RIVER—*M. EDULIS*, UNLESS OTHERWISE INDICATED—74 SAMPLES [1]													
1966	DDE			21	21	24	18	T	19	17	22	42	40
	TDE			33	47	45	49	17	43	38	48	76	59
	DDT			23	37	50	34	13	30	29	22	20	30
	Dieldrin			16	20	23	—	—	—	—	—	31	17
1967	DDE	—	23	24	21	23	21	18	14	20	19	17	18
	TDE	33	53	59	50	18	51	42	38	49	42	35	44
	DDT	13	27	29	33	45	42	33	32	33	27	18	32
	Dieldrin	13	17	27	27	27	22	18	19	15	15	14	17
1968	DDE	14	16	13	17	17	13	11	—	[6] —	[6] —	[6] —	[6] —
	TDE	32	33	36	40	44	49	44	31	—	—	—	T
	DDT	20	18	21	23	42	51	47	25	—	—	—	—
	Dieldrin	14	18	16	18	—	—	—	—	—	—	—	12
1969	DDE	[6] —	[6] T	[3] T	12	[3] T	[3] —	[3] 15	[6] —	10	14	18	20
	TDE	—	T	14	30	12	T	22	T	34	35	49	42
	DDT	—	—	T	22	11	T	14	—	17	30	36	25
	Dieldrin	T	T	T	16	12	117	—	T	24	21	20	20
1970	DDE	16	17	[2] T	—	21	14	18	15	[3] T	14	11	[3] T
	TDE	37	44	18	16	46	37	48	46	17	38	29	14
	DDT	25	33	T	T	38	26	34	30	—	22	17	—
	Dieldrin	27	17	10	16	23	20	24	25	T	24	12	T
1971	DDE	14	T	[2] T	[3] —	[3] —		10	[3] 17		[3] 14	11	[3] —
	TDE	30	16	17	15	12		38	T		10	34	T
	DDT	24	12	T	T	—		20	—		—	13	—
	Dieldrin	14	T	17	20	T		27	—		13	10	—

TABLE I-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—NISSEQUOGUE RIVER—*M. EDULIS*, UNLESS OTHERWISE INDICATED—74 SAMPLES [1]—Continued													
1972	DDE	[3] —	15	[3] T	[3] —	T	T						
	TDE	12	33	12	T	20	14						
	DDT	—	18	T	—	10	T						
	Dieldrin	10	13	T	—	T	12						
STATION 6.—CONSCIENCE BAY—*M. EDULIS*, UNLESS OTHERWISE INDICATED—73 SAMPLES [1]													
1966	DDE			[3] T	[3] —	[5] —	[5] 18	[5] —	[5] —	20	21	24	[6] 17
	TDE			18	—	—	26	—	—	35	34	46	40
	DDT			15	12	—	15	—	—	22	22	30	17
	Dieldrin			—	12	—	—	—	—	—	—	25	—
1967	DDE	18	23	18	18	20	22	21	21	20	18	17	16
	TDE	48	43	33	34	42	44	48	44	36	31	29	31
	DDT	24	23	18	21	29	41	36	35	24	21	18	20
	Dieldrin	17	20	20	30	24	22	21	16	13	15	14	13
1968	DDE	14	16	14	15	T	12	[5] —	[5] —	[5] —	[5] —	[5] —	[5] —
	TDE	23	24	22	27	24	24	—	—	—	—	—	—
	DDT	14	13	17	19	21	21	—	—	—	—	—	—
	Dieldrin	15	14	14	14	—	—	—	—	—	—	—	T
1969	DDE	[5] —	[5] —	[5] —	16	15	[6] 16	[3] 18	[4] 14	[3] 13	17	23	21
	TDE	—	—	—	23	24	36	22	20	14	29	39	36
	DDT	—	—	—	14	32	48	20	—	T	15	26	17
	Dieldrin	—	T	T	14	15	—	T	—	15	26	18	13
1970	DDE		17	22	[3] —	25	21	24	26	[3] —	24	23	18
	TDE		37	37	11	49	45	59	59	17	46	37	26
	DDT		25	36	—	36	29	28	27	—	24	15	14
	Dieldrin		16	19	20	26	20	23	23	T	16	T	10
1971	DDE	[3] T	[3] T	[3] —	16	[3] 10		[6] T	[8] —	[8] —	T	12	[8] T
	TDE	12	15	13	29	15		24	13	13	16	23	11
	DDT	T	10	—	13	—		10	—	T	T	11	—
	Dieldrin	T	14	22	18	—		10	10	17	T	T	11
1972	DDE	[5] —		—	[5] —	—	13						
	TDE	10		18	T	11	21						
	DDT	—		14	—	—	—						
	Dieldrin	—		T	—	75	49						

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—SOUTHOLD—*C. VIRGINICA*, UNLESS OTHERWISE INDICATED—34 SAMPLES[1]													
1969	DDE				[6] 22	[5] T	[5] —	[6] 22		[5] T	[5] T		[6] 20
	TDE				48	11	T	38		14	T		41
	DDT				28	—	—	89		—	—		63
	Dieldrin				—	78	T	—		—	—		T
1970	DDE		[6] 16	29	27	27	[5] 10	21	19		17	22	20
	TDE		32	30	32	35	13	18	19		21	21	21
	DDT		21	26	23	22	—	22	23		18	15	12
	Dieldrin		—	21	20	26	T	11	27		14	15	14
1971	DDE	[5] T	17	17	18	[5] —		10	[5] —	[5] —	[5] —	[5] 15	[5] —
	TDE	16	19	19	17	—		10	T	T	—	18	16
	DDT	—	14	11	12	—		13	—	—	—	13	—
	Dieldrin	21	12	14	16	14		—	—	12	—	T	T
1972	DDE	16	17	18	16	[5] 10	21						
	TDE	27	17	22	21	18	28						
	DDT	16	T	T	11	—	31						
	Dieldrin	14	11	T	10	T	39						
STATION 8.—FLANDERS BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—69 SAMPLES[1]													
1966	DDE			56	28	22	24	—	11	T	T	10	17
	TDE			54	25	21	44	—	23	14	—	15	23
	DDT			89	29	15	—	—	—	—	—	—	—
1967	DDE	15	18	25	23	[3] 23	[3] 20	17	17	16	17	16	15
	TDE	20	27	42	32	58	53	46	47	36	42	37	33
	DDT	—	—	—	—	12	12	—	T	—	—	—	—
1968	DDE	13	10	12	17	10	19	10	T	10	—	T	10
	TDE	25	17	25	41	24	59	44	38	38	18	39	34
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	T	12	[6] 33	15	14	10	12	[6] 20	—		13
	TDE	12	32	25	84	33	28	19	23	49	T		28
	DDT	—	—	—	27	—	—	—	—	75	—		—
	Dieldrin	—	—	—	—	17	107	11	—	14	93		—
1970	DDE			14	[6] T	13	[3] 14	[3] 14			[3] T	T	[3] T
	TDE			26	22	30	29	29			19	T	14
	DDT			—	12	—	—	T			—	—	—
	Dieldrin			11	—	—	—	T			T	—	—

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 8.—FLANDERS BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—69 SAMPLES [1]—Continued													
1971	DDE	—	T	—	T	[6] 16		[3] —	T		13	[3] —	—
	TDE	10	16	—	16	50		16	12		24	—	11
	DDT	—	—	—	—	15		—	—		—	—	—
	Dieldrin	10	T	12	13	T		—	—		T	—	—
1972	DDE	T	—	—	—	—	—						
	TDE	12	—	—	10	T	—						
	DDT	—	—	—	—	—	—						
	Dieldrin	T	—	—	—	—	—						
STATION 9.—MECOX BAY—*C. VIRGINICA*, UNLESS OTHERWISE INDICATED—67 SAMPLES [1]													
1966	DDE			300	120	[3] 22	[3] T	[3] 27	[3] 21	[3] —	46	42	83
	TDE			240	120	41	13	45	29	—	46	37	83
	DDT			56	22	20	—	19	—	—	12	—	—
1967	DDE	63	67	77	T	[3] 37	190	[3] 15	49	64	69	93	110
	TDE	66	60	62	11	67	180	22	52	74	74	100	73
	DDT	—	—	—	—	29	27	T	18	17	11	15	T
1968	DDE		100	53	130	150	130	68	32	34	37	75	30
	TDE		81	48	87	120	85	48	29	18	32	50	18
	DDT		—	—	20	38	48	T	—	—	—	—	—
1969	DDE	44	62	26	60	[3] 20	[3] 21	[3] 19	[3] T	[3] 10	[3] —	[3] 12	
	TDE	31	45	20	39	31	29	21	10	10	—	23	
	DDT	—	—	—	T	24	10	—	—	—	—	—	
	Dieldrin	—	—	—	—	12	—	—	22	—	—	—	
1970	DDE		[3] 19	[3] 21	16	32	[3] 16	21		22	36	[3] T	[3] T
	TDE		27	27	14	45	36	25		38	48	10	12
	DDT		52	49	10	—	32	T		13	13	—	—
	Dieldrin		—	—	—	T	10	—		—	16	—	10
1971	DDE			30	41	34		T	14	37			35
	TDE			24	32	34		10	15	40			46
	DDT			—	T	T		—	—	15			T
	Dieldrin			—	12	T		—	10	19			—
1972	DDE	45	37	26	34	26	35						
	TDE	52	39	26	40	27	38						
	DDT	13	T	—	T	—	12						
	Dieldrin	10	T	10	—	T	—						

TABLE 1-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 10.—SHINNECOCK BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—73 SAMPLES													
1966	DDE			—	—	—	[3] T	—	T	—	—	—	T
	TDE			—	—	—	T	—	14	—	—	—	13
	DDT			—	—	—	—	—	—	—	—	—	—
1967	DDE	T	T	T	59	T	T	—	T	—	T	—	—
	TDE	12	12	12	50	T	T	—	T	—	T	—	—
	DDT	—	—	—	—	—	T	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	10	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	T	[2] 20	—	—	[3]12	[2] 14	[2] 10	[3] —	[2] 13
	TDE	—	T	—	T	38	T	T	21	20	16	—	24
	DDT	—	—	—	—	21	—	—	12	T	T	—	22
	Dieldrin	—	—	—	—	14	T	—	—	T	46	—	—
1970	DDE	[2] 11	[3] —	[3] —	[3] —	[3] 10	[2] 18	[2] 10	[2] 12		[3] —	[3] —	[3] T
	TDE	18	13	T	—	19	34	18	22		—	T	11
	DDT	—	—	—	—	T	21	24	20		T	—	—
	Dieldrin	14	—	12	—	—	12	T	T		12	—	—
1971	DDE		[2] 10	[2] T	[3] —	[3] —		[3] —	—	—	[3] —	[3] —	[3] —
	TDE		17	18	10	10		—	—	T	—	—	T
	DDT		12	14	T	—		—	—	—	—	—	—
	Dieldrin		10	10	—	—		—	44	18	T	T	—
1972	DDE	[3] —	[3] —	[3] —	[2] 11	[2] —	[2] 11						
	TDE	T	T	—	22	11	165						
	DDT	—	—	—	12	T	12						
STATION 11.—MORICHES BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—71 SAMPLES [1]													
1966	DDE			—	—	—	T	—	—	—	—	[3] 15	T
	TDE			—	—	—	10	—	—	—	—	33	14
	DDT			—	—	—	—	—	—	—	—	—	—
1967	DDE	T	T	T	T	T	T	T	T	T	T	T	—
	TDE	13	14	18	13	18	17	10	T	17	T	18	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	T	—	T	T	—	—	—	—	—	—	—	—
	TDE	10	—	14	T	—	—	—	T	—	12	T	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—		—
	TDE	—	11	—	—	13	—	T	T	—	—		T
	DDT	—	—	—	—	—	—	—	—	—	24		—

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 11.—MORICHES BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—71 SAMPLES [1]—Continued													
1970	DDE		—	T	—	T	T	[3] T	[3] 20		[3] 25	[3] 25	[3] 13
	TDE		T	13	—	14	20	21	40		29	19	13
	DDT		—	T	—	—	—	11	23		17	17	T
	Dieldrin		—	—	—	—	T	—	—		14	T	—
1971	DDE		T	[3] 20	[3] 18	—		—	—	—	[3] 22	[3] 10	[3] 21
	TDE		10	27	25	11		—	—	T	15	26	34
	DDT		—	15	14	—		—	—	—	17	T	25
	Dieldrin		T	T	16	—		—	17	18	—	T	T
1972	DDE	[3] 17	[3] 16	[3] 17	[3] 20	[3] 17	[3] 25						
	TDE	27	20	27	26	13	33						
	DDT	19	T	—	15	—	22						
	Dieldrin	T	—	—	T	—	49						
STATION 12.—BELLPORT BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—71 SAMPLES [1]													
1966	DDE			57	—	—	12	T	T	T	14	16	10
	TDE			44	—	10	27	18	13	16	28	30	20
	DDT			31	—	—	T	—	—	—	—	—	—
1967	DDE	20	21	24	19	12	12	11	10	15	T	13	14
	TDE	42	40	45	36	30	31	25	19	26	20	22	27
	DDT	—	—	—	—	T	—	—	T	—	—	—	—
1968	DDE	15	13	15	30	10	T	T	—	T	—	—	—
	TDE	28	24	27	50	23	14	12	—	T	—	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	T	—	[6] 25	T	—	T	—	—	—	—	
	TDE	—	10	—	50	10	15	18	—	—	—	—	
	DDT	—	—	—	33	—	—	—	—	—	—	—	
1970	DDE			T	—	11	10	T	T	—	—	—	
	TDE			13	—	26	17	21	17	—	11	—	
	DDT			—	—	—	T	—	—	—	—	—	
	Dieldrin			—	—	—	T	—	—	37	T	—	
1971	DDE	—	T	T	—	—		—	—	—	—	—	—
	TDE	10	12	11	13	10		—	—	—	—	—	T
	DDT	—	—	—	—	—		—	—	—	—	—	—
	Dieldrin	—	—	12	T	T		T	—	10	—	—	53
1972	DDE	—	—	—	—	—	T						
	TDE	—	T	T	T	—	—						
	DDT	—	—	—	—	—	—						
	Dieldrin	—	16	—	—	—	—						

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 13.—SAYVILLE—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—74 SAMPLES[1]													
1966	DDE			—	—	—	T	—	—	—	—	—	T
	TDE			—	—	T	10	—	—	—	—	—	10
	DDT			—	—	T	T	—	—	—	—	—	—
1967	DDE	T	T	11	T	T	T	T	T	T	—	T	T
	TDE	14	19	24	16	24	14	T	10	T	—	16	19
	DDT	T	—	—	—	T	—	—	T	—	—	—	—
1968	DDE	—	—	—	—	—	—	T	—	—	—	—	—
	TDE	—	—	—	—	—	—	T	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	[4]11	T
	TDE	—	—	—	—	—	—	—	—	T	T	24	13
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	—	—	—	—	—	59	—	19	12
1970	DDE	—	—	—	—	—	T	—	T	T	10	—	T
	TDE	T	13	11	—	T	16	T	14	16	12	T	20
	DDT	—	—	—	—	—	T	10	—	T	T	—	10
	Dieldrin	—	T	—	—	—	T	—	—	—	T	10	T
1971	DDE	T	—	—	—	—		—	—		—	—	—
	TDE	12	T	11	11	10		—	—		—	—	16
	DDT	—	—	—	—	—		—	—		—	—	12
	Dieldrin	T	T	—	—	—		13	—		41	T	11
1972	DDE	[4]22	[4]22	—	17	—	—						
	TDE	56	38	—	16	—	—						
	DDT	29	T	T	10	—	T						
	Dieldrin	15	—	—	11	—	—						
STATION 14.—AMITYVILLE—*M. MERCENARIA*—73 SAMPLES[1]													
1966	DDE			—	—	—	—	—	—	—	—	T	T
	TDE			—	—	—	18	—	—	—	—	10	17
	DDT			—	—	—	—	—	—	—	—	—	—
1967	DDE	T	T	T	T	T	T	—	—	—	—	T	—
	TDE	20	15	16	16	18	14	17	13	T	11	14	—
	DDT	T	—	—	—	T	—	—	T	—	—	—	—
1968	DDE	—	—	—	T	—	—	T	—	T	—	—	—
	TDE	—	—	—	13	—	—	11	T	T	—	13	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 14.—AMITYVILLE—*M. MERCENARIA*—73 SAMPLES [1]—Continued													
1969	DDE	—	—	—	—	—	—	—	—	—	—	20	—
	TDE	—	T	—	T	14	—	T	—	11	T	11	—
	DDT	—	—	—	—	—	—	—	—	—	T	33	—
	Dieldrin	—	—	—	—	T	—	—	—	T	—	T	T
1970	DDE		—	—	—	10	T	T	T	—	—	—	—
	TDE		11	—	T	20	19	15	15	10	T	T	10
	DDT		—	—	—	11	—	—	—	—	—	—	—
	Dieldrin		—	T	—	T	—	—	—	—	18	—	T
1971	DDE		—	—	—	—		—	—	—	—	—	—
	TDE		11	12	T	16		—	T	T	10	—	10
	DDT		—	—	—	—		—	—	T	—	—	—
	Dieldrin		—	—	10	10		—	—	T	—	42	—
1972	DDE	T	—	—	—	—	—						
	TDE	16	T	T	T	—	—						
	DDT	T	—	—	—	—	—						
	Dieldrin	11	—	—	—	—	—						
STATION 15.—EAST BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—57 SAMPLES [1]													
1966	DDE			—	—	—	—	—	—	—	—	T	T
	TDE			—	—	T	—	—	—	—	—	18	19
	DDT			—	—	T	—	—	—	—	—	T	—
1967	DDE	T	—	T	T	—	T	—	—	—	T	T	T
	TDE	21	12	13	15	19	19	15	T	T	13	T	14
	DDT	T	—	—	—	T	T	T	T	—	—	—	T
1968	DDE			T	T	T	—	—	—	—	—	—	—
	TDE			16	10	12	—	—	T	—	12	—	T
	DDT			—	—	—	—	—	—	—	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—		T
	TDE	16	10	—	—	16	14	14	T	T	T		16
	DDT	—	—	—	—	—	—	—	—	—	T		—
	Dieldrin	—	—	—	—	T	10	16	17	T	14		14
1970	DDE	—		—	—							[2] 10	
	TDE	T		12	T							21	
	DDT	—		—	—							18	
	Dieldrin	—		T	—							16	

TABLE J-2.—*Distribution of organochlorine residues in the monitored species for each sampling station by date of collection—New York*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 15.—EAST BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—57 SAMPLES [1]—Continued													
1971	DDE		[2] 12		[6] T	[2] 18		[3] —				—	T
	TDE		29		21	57		19				15	26
	DDT		29		11	23		12				10	23
	Dieldrin		15		11	38		11				—	—
1972	DDE	—			[3] T	[3] —	[3] —						
	TDE	T			14	T	—						
	DDT	—			T	—	—						
STATION 16.—WEST BAY—*M. MERCENARIA*, UNLESS OTHERWISE INDICATED—57 SAMPLES [1]													
1966	DDE				—	T	—	—	—	—	—	T	T
	TDE				—	15	—	—	13	—	—	26	22
	DDT				—	T	—	—	—	—	—	14	13
1967	DDE	T	T	T	—	T	10	T	T	—	T	T	T
	TDE	20	17	24	24	27	32	—	17	T	20	14	19
	DDT	13	T	12	18	17	14	—	13	—	—	—	13
	Dieldrin	—	—	11	12	10	—	—	—	—	—	—	—
1968	DDE			—	T	T	T	—	—	—	—	—	—
	TDE			20	18	13	17	T	15	14	16	15	14
	DDT			—	T	—	—	—	—	—	—	—	—
1969	DDE	—	T	—	—	11	—	—	—	—	—		10
	TDE	19	20	T	—	28	13	18	19	14	21		21
	DDT	—	—	—	—	33	T	—	—	—	12		43
	Dieldrin	—	—	—	—	T	T	18	17	20	12		17
1970	DDE	—		T	—							[2] T	
	TDE	13		20	19							15	
	DDT	—		11	40							15	
	Dieldrin	—		14	T							T	
1971	DDE		[2] 11		[6] T	[2] 15			[6] —			—	10
	TDE		23		22	47			15			14	25
	DDT		28		12	44			—			T	20
	Dieldrin		T		10	16			—			T	10
1972	DDE	—		—	—	[6] 30	[6] 13						
	TDE	10		18	T	59	28						
	DDT	—		14	—	22	T						
	Dieldrin	—		T	—	—	—						

[1] Each sample represents 15 or more mature mollusks.
[2] *M. edulis.*
[3] *M. arenaria.*
[4] *C. virginica.*
[5] *M. mercenaria.*
[6] *M. demissus.*

SECTION K.—NORTH CAROLINA

The monthly collection of eastern oysters, *Crassostrea virginica,* to monitor pollution was initiated in July 1966 and continued until July 1972. During the program, 17 stations were sampled routinely for periods ranging from 3 to 6 years. All samples were analyzed by the Gulf Breeze Laboratory.

Approximate station locations are shown in Fig. K-1. A summary of data on organochlorine residues in the monitored species, *C. virginica,* is presented in Table K-1, and the distribution of residues in this species for each sampling station by date of collection in Table K-2.

North Carolina samples are noteworthy for the continuity of collections of a single species of mollusk at short intervals over a relatively long period of time. For this reason the data present a good picture of annual and seasonal trends of a persistent synthetic pollutant in this estuarine environment.

The incidence of DDT residues (75%) and maximum magnitude (566 ppb) are about the median of the 15 States monitored. The 1% incidence of dieldrin residues was somewhat lower than most other states. PCB compounds were not detected.

Although there are exceptions from one estuary to another, the magnitude of DDT residues in oysters showed little seasonal variation during the period 1967-69 when maximum levels of DDT pollution were detected. The overall decline in DDT residues (Part I. Table 7 and Fig. 2) is notable and undoubtedly associated with the decreased agricultural use of this chemical in North Carolina.

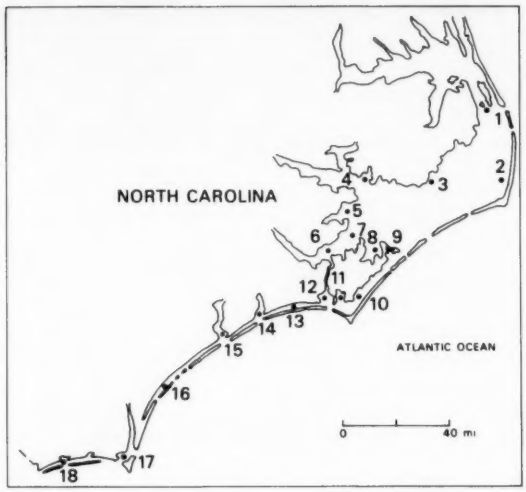

FIGURE K-1.—*Diagram of coastal North Carolina showing approximate location of monitoring stations*

1. Wanchese—Croatan Sound
2. Salvo—Pamlico Sound
3. Wysocking Bay
4. Rose Bay
5. Bay River
6. Neuse River
7. Point of Marsh—Neuse River
8. West Bay
9. Back Bay—Core Sound
10. Jarrett Bay—Core Sound
11. North River
12. Newport River
13. Bogue Sound
14. White Oak River
15. New River
16. Wrightsville Beach—Wrightsville Sound
17. Southport—Cape Fear River
18. Shallotte River

TABLE K-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1966-72—North Carolina*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µg/kg)	
				DDT	Dieldrin
1 *	Wanchese	1966-72	72	49 (264)	
2 *	Salvo	1966-72	71	58 (566)	
3	Wysocking Bay	1966-70	43	35 (64)	
4 *	Rose Bay	1966-72	71	46 (121)	3 (14)
5 *	Bay River	1966-72	71	69 (310)	2 (12)
6	Neuse River	1966-70	43	43 (176)	
7 *	Point of Marsh	1966-72	71	53 (139)	2 (19)
8	West Bay	1967-72	58	34 (74)	
9	Back Bay	1966-67	9	8 (103)	
10 *	Jarrett Bay	1966-72	66	42 (106)	
11 *	North River	1966-72	64	48 (172)	2 (10)
12 *	Newport River	1966-72	68	54 (121)	3 (13)

TABLE K-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1966-72—North Carolina*—Continued

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
				DDT	Dieldrin
13	Bogue Sound	1967-72	51	33 (71)	
14	White Oak River	1966-70	43	30 (60)	
15 *	New River	1966-72	72	61 (118)	
16	Wrightsville Beach	1966-70	43	35 (57)	
17 *	Southport	1966-72	72	32 (116)	
18	Shallotte River	1966-70	43	38 (51)	
Total number of samples			1,031		
Percent of samples positive for indicated compound				75	1

* Data from these stations summarized in Part I. Table 7. and Fig. 2.
[1] Each sample represents 15 or more mature mollusks.

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—WANCHESE—72 SAMPLES [1]													
1966	DDE							19	20	12	22	20	20
	TDE							12	17	T	17	18	32
	DDT							13	—	T	22	—	11
1967	DDE	14	25	28	16	26	21	21	19	20	24	43	28
	TDE	16	20	32	17	32	31	35	15	15	11	57	10
	DDT	15	10	17	—	29	21	64	17	13	17	64	53
1968	DDE	140	140	85	78	62	T	30	—	43	35	29	21
	TDE	56	51	59	16	32	T	13	—	22	27	16	15
	DDT	68	29	37	42	86	—	12	—	60	49	57	—
1969	DDE	40	17	13	10	37	11	T	10	—	T	T	12
	TDE	15	16	18	10	44	21	21	10	—	T	13	15
	DDT	T	T	11	—	43	T	19	13	—	—	—	T
1970	DDE	T	T	13	T	17	—	—	—	—	—	—	—
	TDE	11	T	15	—	19	—	—	—	—	11	—	—
	DDT	—	—	T	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	T	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1972	DDE	—	—	—	T	—	T						
	TDE	—	—	—	—	—	10						
	DDT	—	—	—	—	—	—						

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—SALVO—71 SAMPLES[1]													
1966	DDE							12	14	14	14	32	23
	TDE							—	17	—	17	28	17
	DDT							—	—	—	—	28	15
1967	DDE	26	24	31	35	24	21	17	24		120	74	87
	TDE	11	13	21	25	21	30	21	19		56	45	29
	DDT	T	T	T	11	19	21	29	44		390	190	66
1968	DDE	35	85	66	85	65	34	58	28	95	45	58	66
	TDE	16	26	20	24	37	29	38	21	40	33	37	35
	DDT	20	50	36	21	28	19	87	36	240	76	120	80
1969	DDE	100	73	100	59	120	39	27	—	15	13	10	15
	TDE	31	31	38	27	51	38	37	—	21	15	19	13
	DDT	87	35	50	22	67	16	28	—	T	T	—	11
1970	DDE	23	34	24	19	27	14	—	12	11	—	10	19
	TDE	25	27	20	16	33	20	—	17	—	—	—	16
	DDT	14	20	13	10	19	—	—	14	—	—	—	11
1971	DDE	16	15	—	17	21	—	12	—	—	—	—	—
	TDE	17	16	—	18	21	—	14	—	—	—	—	—
	DDT	T	—	—	—	11	—	—	—	—	—	—	—
1972	DDE	—	—	—	T	13	13						
	TDE	—	—	—	—	T	22						
	DDT	—	—	—	—	—	—						
STATION 3.—WYSOCKING BAY—43 SAMPLES[1]													
1966	DDE							17	—	17	T	T	T
	TDE							17	—	18	13	12	11
	DDT							—	—	20	—	—	—
1967	DDE	T	14	15	17	16	12	15	T	—	—	T	10
	TDE	12	17	17	22	29	22	35	T	—	—	T	15
	DDT	T	10	—	—	14	13	14	T	—	—	T	T
1968	DDE	T	T	T	18	13	15	—	T	T	—	T	—
	TDE	T	T	—	20	20	13	—	T	T	—	13	—
	DDT	—	—	—	—	T	13	—	—	21	—	—	—
1969	DDE	T	—	T	12	T	T	T	T	—	T	T	14
	TDE	14	—	—	16	T	T	T	—	—	T	12	19
	DDT	—	—	—	T	—	—	T	12	—	—	—	12
1970	DDE	T											
	TDE	T											
	DDT	T											

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		STATION 4.—ROSE BAY—71 SAMPLES[1]											
1966	DDE							28	16	19	18	16	20
	TDE							34	13	22	23	23	36
	DDT							21	—	32	16	T	14
1967	DDE	12	T	23	15	16	15	35	T	T	—	14	12
	TDE	18	14	32	26	32	30	63	15	10	—	30	15
	DDT	T	T	T	11	16	40	23	13	T	—	19	T
1968	DDE	T	T	13	15	21	14	T	—	T	T	T	16
	TDE	T	T	12	15	27	25	T	—	T	17	17	17
	DDT	—	—	—	22	13	T	—	—	T	T	T	29
1969	DDE	11	16	11	T	12	T	T	T	12	T	—	10
	TDE	15	18	12	—	17	T	T	13	17	T	—	14
	DDT	20	—	—	—	T	—	T	69	—	—	—	T
1970	DDE	17	13	14	T	T		11	—	—	—	—	—
	TDE	19	19	19	—	15		19	—	—	—	—	—
	DDT	15	10	10	—	—		12	—	—	—	—	—
	Dieldrin	—	—	14	—	—		—	—	—	—	—	—
1971	DDE	—	—	—	—	T	—	—	—	—	—	—	—
	TDE	—	—	—	—	13	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	10	—	12	—	—	—	—	—	—	—
1972	DDE	—	—	—	—	—	—						
	TDE	—	—	—	—	—	—						
	DDT	—	—	—	—	—	—						
		STATION 5.—BAY RIVER—71 SAMPLES[1]											
1966	DDE							36	55	52	23	30	26
	TDE							36	78	73	46	61	60
	DDT							29	25	34	19	11	20
1967	DDE	36	30	81	39	32	29	22	15	T	28	25	24
	TDE	69	49	100	56	65	56	46	48	T	43	34	46
	DDT	23	16	35	20	27	19	27	27	—	51	—	16
1968	DDE	35	44	37	52	75	22	18	23	13	T	24	16
	TDE	35	43	24	49	71	33	24	28	15	—	36	21
	DDT	26	32	28	47	55	T	13	18	12	—	29	T
1969	DDE	19	29	36	43	54	45	37	18	T	13	T	20
	TDE	25	39	36	56	59	80	71	16	T	T	20	35
	DDT	T	20	37	37	32	17	26	18	14	—	—	21

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—BAY RIVER—71 SAMPLES[1]—Continued													
1970	DDE	24	40	36	42	55	10	15	11	13	—		23
	TDE	33	43	29	31	94	27	23	12	22	16		39
	DDT	17	33	18	14	22	—	18	—	14	—		13
1971	DDE	12	16	—	22	110	16	52	49	18	17	13	T
	TDE	15	13	—	21	170	19	97	96	34	26	11	—
	DDT	—	10	—	—	30	—	27	22	—	18	12	—
	Dieldrin	—	—	—	—	10	—	—	—	—	—	—	—
1972	DDE	16	41	—	71	85	43						
	TDE	11	37	—	48	130	91						
	DDT	—	21	—	37	87	43						
	Dieldrin	—	—	—	—	12	—						
STATION 6.—NEUSE RIVER—43 SAMPLES[1]													
1966	DDE							29	18	32	36	24	29
	TDE							46	24	48	57	55	60
	DDT							13	15	49	30	13	18
1967	DDE	17	16	24	29	21	16	19	14	20	25	24	24
	TDE	29	28	41	50	42	30	37	33	32	47	49	46
	DDT	—	T	T	T	T	16	25	14	14	13	T	T
1968	DDE	19	20	15	30	49	32	26	29	13	T	19	25
	TDE	24	25	15	44	110	68	42	56	22	T	32	25
	DDT	11	T	—	27	17	15	19	39	T	—	T	20
1969	DDE	20	17	23	16	37	29	30	13	T	10	T	16
	TDE	17	13	26	23	56	75	40	23	T	17	19	35
	DDT	10	T	11	—	20	21	20	11	—	—	—	16
1970	DDE	27											
	TDE	45											
	DDT	17											
STATION 7.—POINT OF MARSH—71 SAMPLES[1]													
1966	DDE							33	26	15	29	16	20
	TDE							37	26	20	31	33	40
	DDT							38	28	25	19	16	16
	Dieldrin							T	—	—	—	—	—
1967	DDE	15	17	22	20	20	33	13	22	11	12	11	18
	TDE	29	24	28	32	39	82	26	24	19	19	18	25
	DDT	15	10	—	11	45	24	27	33	10	27	15	10

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—POINT OF MARSH—71 SAMPLES [1]—Continued													
1968	DDE	11	—	12	18	11	15	10	15	—	T	14	11
	TDE	15	—	18	23	18	20	13	19	—	T	21	16
	DDT	T	—	—	21	10	16	11	21	—	—	—	—
1969	DDE	13	T	12	T	T	T	10	37	—	T	T	T
	TDE	14	14	17	13	T	11	16	27	—	T	11	10
	DDT	—	T	T	—	—	—	18	48	—	T	12	—
	Dieldrin	—	—	—	—	—	—	—	19	—	—	—	—
1970	DDE	11	22	20	T	T		—	—	—	—	T	—
	TDE	21	29	21	12	17		—	—	—	—	T	—
	DDT	T	15	—	—	—		—	—	—	—	—	—
1971	DDE	—	T	T	T	T	—	—	—	—	—	—	T
	TDE	—	T	T	32	—	—	—	—	—	—	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	T
1972	DDE	11	—	—	T	T	—						
	TDE	20	—	—	—	T	—						
	DDT	—	—	—	—	—	—						
STATION 8.—WEST BAY—58 SAMPLES [1]													
1967	DDE		18	25			22	14	T	—	16	T	15
	TDE		25	39			22	19	T	—	22	10	24
	DDT		T	11			13	11	T	—	17	12	15
1968	DDE	T	11	25	T	16	11	—	T	—	T	—	10
	TDE	—	11	30	T	13	T	—	T	—	—	—	16
	DDT	—	—	19	—	T	—	—	15	—	—	—	—
1969	DDE	16	T	20	16	11	T	12	—	—	—	T	T
	TDE	10	T	17	19	T	12	16	—	—	—	16	17
	DDT	T	—	12	12	10	T	T	—	—	—	—	T
1970	DDE	—				—	—	—	—	—	—	T	T
	TDE	—				—	—	—	—	—	—	T	16
	DDT	—				—	—	—	—	—	—	—	—
1971	DDE	—	T	—	—	T	—	—	—	—	T	—	
	TDE	—	T	—	—	—	—	—	—	—	T	—	
	DDT	—	—	—	—	—	—	—	—	—	T	—	
1972	DDE		—	13	14	11	—						
	TDE		—	10	T	T	—						
	DDT		—	—	—	—	—						

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 9.—BACK BAY—9 SAMPLES[1]													
1966	DDE							10	—	15	17	24	10
	TDE							12	—	11	32	74	14
	DDT							14	—	12	15	T	—
1967	DDE	10			26	10							
	TDE	10			23	13							
	DDT	—			17	T							
STATION 10.—JARRETT BAY—66 SAMPLES[1]													
1966	DDE							22	—	13	14	T	12
	TDE							22	—	11	16	T	18
	DDT							15	—	19	16	—	14
1967	DDE	11	17	14	29	19	17	10	12	12	14	10	21
	TDE	T	12	19	24	22	18	12	T	T	18	17	17
	DDT	—	T	—	17	14	10	T	12	T	39	13	12
1968	DDE	18	13	47	T	10	T	—	13	T	18	—	T
	TDE	14	10	44	T	—	—	—	T	T	13	—	15
	DDT	T	T	15	—	—	—	—	T	T	66	—	T
1969	DDE	12	T	12	21	13	T	10	—	—	—	10	12
	TDE	T	11	16	22	12	10	15	—	—	—	18	22
	DDT	—	T	T	—	T	—	—	—	—	—	—	11
1970	DDE	T				—	—	—	—	—	—	—	—
	TDE	T				—	—	—	—	—	—	—	—
	DDT	T				—	—	—	—	—	—	—	—
1971	DDE	—	T	—	—	11	—	—	—	—	T	—	
	TDE	—	T	—	—	10	—	—	—	—	T	—	
	DDT	—	—	—	—	—	—	—	—	—	T	—	
1972	DDE			—	12	T	—						
	TDE			—	—	—	—						
	DDT			—	—	—	—						
STATION 11.—NORTH RIVER—64 SAMPLES[1]													
1966	DDT							64	43	43	47	36	35
	TDE							50	33	41	47	33	29
	DDT							58	36	31	30	10	—
	Dieldrin							10	—	—	—	—	—
1967	DDE	27	26	45	11	52	53	34	21	16	17	10	20
	TDE	15	18	40	12	46	49	28	20	12	12	10	16
	DDT	10	16	27	—	29	31	15	26	T	10	—	T
	Dieldrin	—	—	10	—	—	—	—	—	—	—	—	—

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 11.—NORTH RIVER—64 SAMPLES [1]—Continued													
1968	DDE	18	14	T	35	34	T	32	21	T	22	38	27
	TDE	13	—	—	25	26	—	27	19	T	17	20	—
	DDT	T	—	—	43	36	—	57	26	T	36	27	—
1969	DDE	18	13	16	32	16	T	—	—	12	53	—	T
	TDE	T	—	T	15	12	—	—	—	T	73	—	T
	DDT	—	—	12	14	—	—	—	—	11	34	—	T
1970	DDE	T				11	—	—	—	—	—	—	T
	TDE	T				11	—	—	—	—	—	—	—
	DDT	T				—	—	—	—	—	—	—	—
1971	DDE	—		—	12	T	T	—	—	—	—		
	TDE	—		—	—	—	—	—	—	—	—		
	DDT	—		—	—	—	—	—	—	—	—		
1972	DDE			20	10	T	—						
	TDE			—	—	—	—						
	DDT			11	—	—	—						
STATION 12.—NEWPORT RIVER—68 SAMPLES [1]													
1966	DDE							20	17	14	16	24	14
	TDE							21	13	19	26	44	22
	DDT							—	T	T	—	11	—
	Dieldrin							T	—	—	—	—	—
1967	DDE	14	18	25	20	21	19	T	T	14	16	12	16
	TDE	21	24	85	27	29	30	12	15	25	18	17	26
	DDT	T	T	11	T	—	T	10	T	15	23	—	T
1968	DDE	11	16	17	25	—	T	T	T	11	18	19	15
	TDE	14	16	23	31	—	—	T	T	13	24	29	18
	DDT	—	—	T	—	—	—	—	—	T	23	11	T
1969	DDE	21	21	20	27	17	12	T	—	T	13	15	18
	TDE	21	22	21	29	23	19	T	—	T	16	15	17
	DDT	—	10	T	13	T	T	—	—	—	25	17	17
	Dieldrin	—	—	—	—	—	—	—	—	—	T	—	—
1970	DDE	16	12	12	18	T	—	T		—	—	T	
	TDE	14	T	10	23	T	—	—		—	—	T	
	DDT	13	—	T	10	—	—	—		—	—	—	
1971	DDE	—	11		—	13	—	—	17	—	—	—	—
	TDE	—	11		—	18	—	—	16	—	—	—	—
	DDT	—	—		—	—	—	—	—	—	—	—	—

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 12.—NEWPORT RIVER—68 SAMPLES [1]—Continued													
1972	DDE	—		30	T	T	T						
	TDE	—		24	—	—	—						
	DDT	—		36	—	—	—						
	Dieldrin	—		13	—	—	—						
STATION 13.—BOGUE SOUND—51 SAMPLES [1]													
1967	DDE			31	20	15	T	10	10	13	15	14	15
	TDE			26	23	17	T	12	12	14	—	13	T
	DDT			12	T	T	—	11	16	24	T	12	T
1968	DDE	12	T	16	15	T	—	T	T	13	13	21	18
	TDE	T	—	—	T	—	—	—	T	13	13	17	11
	DDT	—	—	—	—	—	—	—	T	21	T	13	11
1969	DDE	20	29	17	25	19	T	15	—	—	12	13	12
	TDE	15	23	11	20	19	11	16	—	—	14	17	—
	DDT	T	19	T	12	11	11	37	—	—	T	15	—
1970	DDE					—							
	TDE					—							
	DDT					—							
1971	DDE			—	—	T	—	—	—	—	—	—	—
	TDE			—	—	—	—	—	—	—	—	—	—
	DDT			—	—	—	—	—	—	—	—	—	—
1972	DDE	—	—	T	—	—	—						
	TDE	—	—	—	—	—	—						
	DDT	—	—	—	—	—	—						
STATION 14.—WHITE OAK RIVER—43 SAMPLES [1]													
1966	DDE							T	20	T	29	T	T
	TDE							—	25	T	31	T	T
	DDT							—	T	—	—	—	—
1967	DDE	—	—	T	—	T	—	T	—	T	T	T	T
	TDE	—	—	—	—	T	—	13	—	T	—	T	T
	DDT	—	—	—	—	—	—	10	—	T	—	—	—
1968	DDE	T	T	13	T	—	—	—	T	11	T	T	14
	TDE	T	T	13	T	—	—	—	T	11	—	T	T
	DDT	T	—	—	—	—	—	—	T	T	—	—	T
1969	DDE	T	12	14	T	T	—	—	—	—	T	T	—
	TDE	—	—	T	—	T	—	—	—	—	T	T	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 14.—WHITE OAK RIVER—43 SAMPLES [1]—Continued													
1970	DDE	T											
	TDE	—											
	DDT	—											
STATION 15.—NEW RIVER—72 SAMPLES [1]													
1966	DDE							25	T	23	21	28	36
	TDE							21	T	27	26	34	44
	DDT							28	—	T	—	—	14
1967	DDE	39	16	30	45	20	16	11	19	16	28	21	28
	TDE	49	18	30	59	23	13	13	28	20	34	26	37
	DDT	16	T	T	14	—	—	—	11	—	—	—	21
1968	DDE	42	16	35	39	25	15	T	10	14	15	15	14
	TDE	38	14	31	29	25	15	—	T	14	12	12	T
	DDT	31	T	T	—	—	—	—	T	T	—	—	—
1969	DDE	25	18	21	28	13	15	11	13	14	19	23	27
	TDE	19	19	27	35	13	15	15	13	12	22	26	27
	DDT	—	T	T	T	—	—	—	T	—	11	—	11
1970	DDE	21	28	29	26	26	T	—	—	—	—	—	17
	TDE	19	24	22	31	20	—	—	—	—	—	—	—
	DDT	—	T	T	12	—	—	—	—	—	—	—	—
1971	DDE	11	T	15	T	T	—	—	—	—	12	—	20
	TDE	—	T	12	—	—	—	—	—	—	11	—	22
	DDT	—	—	—	—	—	—	—	—	—	T	—	T
1972	DDE	19	17	24	11	T	—						
	TDE	18	21	21	—	—	—						
	DDT	—	—	—	—	—	—						
STATION 16.—WRIGHTSVILLE BEACH—43 SAMPLES [1]													
1966	DDE							11	14	15	15	19	12
	TDE							12	18	12	16	24	10
	DDT							—	—	—	13	14	—
1967	DDE	11	16	19	14	T	T	T	10	—	T	—	11
	TDE	14	18	15	14	T	T	14	18	—	12	—	13
	DDT	—	T	T	—	T	—	T	14	—	22	—	T
1968	DDE	T	T	10	13	T	—	—	10	T	T	T	T
	TDE	T	—	—	10	T	—	—	—	—	—	12	—
	DDT	T	—	—	—	—	—	—	T	—	—	—	—

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µG/KG)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 16.—WRIGHTSVILLE BEACH—43 SAMPLES [1]—Continued													
1969	DDE	T	T	T	T	T	—	—	—	—	T	T	12
	TDE	—	—	—	T	T	—	—	—	—	T	11	16
	DDT	—	—	—	—	—	—	—	—	—	—	—	12
1970	DDE	T											
	TDE	—											
	DDT	—											
STATION 17.—SOUTHPORT—72 SAMPLES [1]													
1966	DDE							11	21	11	29	T	T
	TDE							T	16	10	25	T	T
	DDT							12	—	—	—	—	—
1967	DDE	T	13	11	T	—	T	10	14	11	T	—	T
	TDE	—	12	T	T	—	—	10	T	—	—	—	T
	DDT	—	T	—	—	—	—	17	30	15	—	—	—
1968	DDE	18	13	T	T	11	—	—	10	11	T	17	17
	TDE	13	T	T	T	14	—	—	—	T	11	—	T
	DDT	T	—	—	—	—	—	—	13	T	—	21	10
1969	DDE	T	—	12	T	11	—	—	—	—	—	—	—
	TDE	—	—	17	—	12	—	—	—	—	—	—	—
	DDT	—	—	87	—	T	—	—	—	—	—	—	—
1970	DDE	—	T	—	—	—	—	—	T	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1972	DDE	—	—	—	—	—	—						
	TDE	—	—	—	—	—	—						
	DDT	—	—	—	—	—	—						
STATION 18.—SHALLOTTE RIVER—43 SAMPLES [1]													
1966	DDE							—	T	T	T	19	T
	TDE							—	—	T	—	18	T
	DDT							—	—	—	—	11	—
1967	DDE	T	16	11	14	19	T	T	T	10	T	12	T
	TDE	—	13	T	15	22	T	11	T	T	—	11	T
	DDT	—	T	—	—	10	—	10	T	T	—	T	—

TABLE K-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—North Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 18.—SHALLOTTE RIVER—43 SAMPLES [1]—Continued													
1968	DDE	13	14	16	15	—	—	—	T	T	13	—	17
	TDE	11	10	11	12	—	—	—	—	—	T	—	10
	DDT	T	T	—	—	—	—	—	—	—	11	—	T
1969	DDE	T	T	12	11	15	T	14	T	T	11	T	T
	TDE	—	—	10	T	19	—	14	T	—	T	13	—
	DDT	—	—	19	—	T	—	16	16	12	T	—	—
1970	DDE	T											
	TDE	—											
	DDT	—											

[1] Each sample represents 15 or more mature mollusks.

SECTION L.—SOUTH CAROLINA

Monthly collections of eastern oysters, *Crassostrea virginica,* to identify estuarine pollution were made from August 1965 through November 1969. The 17 stations (Fig. L-1) were monitored for periods ranging from 1 to 5 years. All samples were analyzed at the Gulf Breeze Laboratory. A summary of data on organochlorine residues in the monitored species, *C. virginica,* is presented in Table L-1, and the distribution of residues in this species for each sampling station by date of collection in Table L-2.

South Carolina samples are characterized by the uniformly low level of DDT residues and moderately low incidence of positive samples. Samples from only three other States indicated generally lower levels of DDT contamination.

In those areas with adequate numbers of samples for annual comparison, there was an obvious decline at most stations in the magnitude and incidence of DDT residues in 1968-69 as compared to earlier years (Part I. Table 6).

South Carolina was the only State in which mirex residues were detected in mollusks. These residues were observed only in the period March - May 1969. They were found at nine stations widely distributed along the South Carolina coast. Largest residues were found in samples collected in the Charleston area, i.e., Stations 8 and 9.

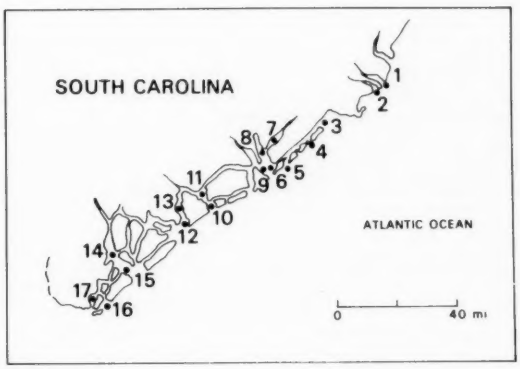

FIGURE L-1.—*Diagram of coastal South Carolina showing approximate location of monitoring stations*

1. North Santee Bay—Santee River
2. South Santee Bay—Santee River
3. Bull Creek
4. Price Creek
5. Inlet Creek
6. Hog Island Channel—Ashley, Cooper, and Wando Rivers
7. Wando River—Ashley, Cooper, and Wando Rivers
8. Ashley River—Ashley, Cooper, and Wando Rivers
9. Fort Johnson—Ashley, Cooper, and Wando Rivers
10. Steamboat Creek—North Edesto River
11. Toogoodoo Creek—North Edesto River
12. Big Bay Creek—South Edesto River
13. St. Pierre Creek—South Edesto River
14. Whale Branch—Broad River
15. Skull Creek—Broad River
16. May Creek
17. New River

TABLE L-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-69—South Carolina*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)					
				DDT		Dieldrin		Mirex	
1	North Santee Bay	1965-68	41	10	(19)	4	(19)		
2	South Santee Bay	1965-68	40	14	(80)	3	(19)		
3	Bull Creek	1969	12	2	(10)	2	(13)	2	(35)
4	Price Creek	1965-68	42	25	(81)	2	(12)		
5	Inlet Creek	1965-68	42	21	(52)				
6	Hog Island Channel	1965-68	41	33	(73)				
7	Wando River	1965-68	42	31	(44)				
8	Ashley River	1965-69	54	45	(154)	8	(90)	1	(190)
9	Fort Johnson	1969	12	4	(10)			1	(540)
10	Steamboat Creek	1965-69	54	26	(32)			1	(38)
11	Toogoodoo Creek	1965-69	53	40	(98)			1	(38)
12	Big Bay Creek	1965-69	54	32	(91)			1	(T)
13	St. Pierre Creek	1969	12	7	(88)			1	(38)
14	Whale Branch	1965-68	41	21	(79)				
15	Skull Creek	1965-68	39	12	(30)	1	(35)		
16	May Creek	1969	12	3	(15)	1	(11)	3	(37)
17	New River	1969	12	1	(16)	1	(21)	1	(27)
	Occasional stations (6)	1965-68	7	5	(201)	2	(15)		
Total number of samples			610						
Percent positive for indicated compound				54		4		2	

NOTE: T = >5 but <10 ppb.
[1] Each sample represents 15 or more mature mollusks.

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*

[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—NORTH SANTEE BAY—41 SAMPLES [1]													
1965	DDE							T	T	T	—	—	—
	TDE							T	T	T	—	—	—
	DDT							—	—	—	T	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—		—	T	T	T	—	—	—	—
	TDE	—	—	—		—	—	—	—	—	—	—	—
	DDT	—	—	—		—	—	T	T	—	—	—	—
	Dieldrin	—	—	15		—	—	—	—	—	—	—	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—NORTH SANTEE BAY—41 SAMPLES[1]—Continued													
1968	DDE	T	—	—	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	19	—	—
	Dieldrin	15	—	12	19	—	—	—	—	—	—	—	—
STATION 2.—SOUTH SANTEE BAY—40 SAMPLES[1]													
1965	DDE							T	T	T	—	—	—
	TDE							T	T	—	—	—	—
	DDT							—	—	—	T	—	—
1966	DDE	—	—	—	—	T	—	—	—	—		—	—
	TDE	—	—	—	—	—	—	—	—	—		—	—
	DDT	—	—	—	—	—	—	—	—	—		—	—
1967	DDE	—	—	T		—	—	T	T	T	—	—	—
	TDE	—	—	—		—	—	T	—	—	—	—	—
	DDT	—	—	—		—	—	13	T	T	—	—	—
1968	DDE	T	46	—	10	T	—	—	T	—	—	—	—
	TDE	T	—	—	T	—	—	—	—	—	—	—	—
	DDT	T	34	—	—	—	—	—	12	—	—	—	—
	Dieldrin	—	13	10	19	—	—	—	—	—	—	—	—
STATION 3.—BULL CREEK—12 SAMPLES[1]													
1969	DDE	—	—	—	T	T	—	—	—	—	—	—	—
	TDE	—	—	—	T	T	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	13	12	—	—	—	—	—	—	—
	Mirex	—	—	22	—	35	—	—	—	—	—	—	—
STATION 4.—PRICE CREEK—42 SAMPLES[1]													
1965	DDE							T	—	T	—	—	—
	TDE							T	—	—	—	—	—
	DDT							—	—	—	—	—	—
1966	DDE	T	—	T	—	—	—	—	—	19	T	—	T
	TDE	—	—	—	—	—	—	—	—	36	—	—	T
	DDT	—	—	—	—	—	—	—	—	26	—	—	—
	Dieldrin	—	—	12	—	—	—	—	—	—	—	—	—
1967	DDE	T	11	12	T	T	T	T	13	T	—	10	T
	TDE	—	T	—	—	—	10	T	12	—	—	T	T
	DDT	—	T	—	—	T	11	10	11	T	—	T	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—PRICE CREEK—42 SAMPLES[1]—Continued													
1968	DDE	T	T	T	11	T	—	T	—	—	T	—	—
	TDE	10	T	—	T	—	—	—	—	—	—	—	—
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	10	—	—	—	—	—	—	—	—	—	—
STATION 5.—INLET CREEK—42 SAMPLES[1]													
1965	DDE							T	T	—	—	T	T
	TDE							T	T	—	—	—	T
	DDT							—	T	—	—	—	—
1966	DDE	T	—	—	—	14	—	—	T	—	T	T	T
	TDE	T	—	—	—	14	—	—	—	—	—	—	T
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	T	T	T	14	T	T	T	16	—	—	—	T
	TDE	—	—	T	13	—	—	15	21	—	—	—	—
	DDT	—	—	—	12	T	—	17	15	—	—	—	—
1968	DDE	11	—	12	—	—	—	—	—	—	—	—	—
	TDE	11	—	T	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 6.—HOG ISLAND CHANNEL—41 SAMPLES[1]													
1965	DDE							T	T	T	T	T	—
	TDE							T	T	—	T	—	—
	DDT							T	—	—	T	—	—
1966	DDE	T	13	T	14	13	—	20	—	14	10	—	T
	TDE	T	T	—	—	15	T	15	—	—	—	—	—
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	15	20	20	16	14	11	10	19	T	—	T	T
	TDE	14	13	—	—	32	11	13	28	T	—	T	T
	DDT	11	11	—	—	12	20	14	26	11	—	16	—
1968	DDE	T	13	12	20	—	—	T	—	—	T	T	
	TDE	—	10	—	16	—	—	10	—	—	—	—	
	DDT	—	—	—	14	—	—	T	—	—	—	—	
STATION 7.—WANDO RIVER—42 SAMPLES[1]													
1965	DDE							T	T	T	T	—	T
	TDE							T	T	T	T	—	T
	DDT							T	T	—	T	—	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—WANDO RIVER—42 SAMPLES [1]—Continued													
1966	DDE	10	—	T	11	10	—	—	—	10	10	T	T
	TDE	10	—	—	—	12	—	—	—	13	12	11	14
	DDT	T	—	—	—	—	—	—	—	T	—	—	T
1967	DDE	10	12	16	T	T	T	—	10	T	T	T	11
	TDE	17	13	17	—	T	T	12	20	10	T	—	16
	DDT	—	—	—	—	—	T	10	14	10	—	—	T
1968	DDE	14	13	11	14	13	—	T	—	—	—	—	—
	TDE	18	T	T	T	14	—	10	—	—	—	—	—
	DDT	12	—	—	—	—	—	T	—	—	—	—	—
STATION 8.—ASHLEY RIVER—54 SAMPLES [1]													
1965	DDE							16	T	T	T	18	32
	TDE							16	T	T	15	27	22
	DDT							14	T	—	10	28	22
1966	DDE	33	34	38	35	25	16	13	11	—	T	25	18
	TDE	25	29	28	33	23	39	17	—	—	T	31	28
	DDT	28	30	16	22	14	—	—	—	—	11	31	21
	Dieldrin	—	13	21	20	90	—	—	—	—	—	—	—
1967	DDE	36	36	51	26	42	11	16	18	T	14	23	33
	TDE	21	28	39	21	69	—	20	23	10	19	26	37
	DDT	24	28	35	18	43	19	18	32	11	18	42	49
	Dieldrin	—	—	11	—	—	—	—	—	—	—	—	—
1968	DDE	31	15	66	35	32	T	13	15	T	T	T	60
	TDE	30	13	26	31	28	—	16	15	11	—	—	51
	DDT	28	—	25	23	25	—	14	11	13	—	T	28
	Dieldrin	T	—	19	—	—	—	—	—	—	—	—	—
1969	DDE	12	13	16	—	15	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	13	—	—	—	—	—	—	—
	Dieldrin	—	—	—	—	—	—	—	—	—	—	23	—
	Mirex	—	—	190	—	—	—	—	—	—	—	—	—
STATION 9.—FORT JOHNSON—12 SAMPLES [1]													
1969	DDE	—	—	T	T	—	—	—	—	—	T	—	T
	TDE	—	—	—	—	—	—	—	—	—	T	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Mirex	—	—	540	—	—	—	—	—	—	—	—	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 10.—STEAMBOAT CREEK—54 SAMPLES[1]													
1965	DDE							T	T	T	—	T	—
	TDE							T	T	—	—	—	—
	DDT							—	T	—	—	—	—
1966	DDE	T	T	—	14	—	11	—	T	—	T	—	—
	TDE	—	—	—	11	—	11	—	—	T	T	—	—
	DDT	—	—	—	—	—	—	—	—	T	—	—	—
1967	DDE	T	11	10	—	13	T	—	—	T	—	—	—
	TDE	T	T	10	—	14	T	—	—	T	—	—	T
	DDT	—	—	T	—	T	16	—	—	T	—	—	T
1968	DDE	T	T	—	T	T	—	T	—	—	—	—	—
	TDE	T	—	—	—	—	—	—	—	—	—	—	—
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
1969	DDE	—	T	—	—	—	—	—	—	—	—	T	T
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Mirex	—	—	38	—	—	—	—	—	—	—	—	—
STATION 11.—TOOGOODOO CREEK—53 SAMPLES[1]													
1965	DDE							32	14	18	16	20	16
	TDE							43	20	19	20	33	16
	DDT							T	T	T	—	T	—
1966	DDE	27	18	15	38	24	19	—	15	13	18	11	22
	TDE	25	20	13	36	33	20	—	16	13	18	12	26
	DDT	—	T	T	24	16	—	—	—	11	10	—	T
1967	DDE	10	20	21	25	21	14	T	—		12	T	30
	TDE	T	17	18	23	22	15	—	—		—	—	26
	DDT	—	—	T	—	14	T	—	—		—	—	12
1968	DDE	17	20	16	18	25	21	T	18	11	T	T	13
	TDE	14	16	—	16	20	16	T	19	10	—	—	T
	DDT	T	—	—	—	—	—	—	17	T	—	—	—
1969	DDE	—	—	—	—	—	—	—	—	—	—	T	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Mirex	—	—	38	—	—	—	—	—	—	—	—	—
STATION 12.—BIG BAY CREEK—54 SAMPLES[1]													
1965	DDE							T	T	T	T	—	T
	TDE							T	T	—	T	—	T
	DDT							—	—	—	—	—	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 12—BIG BAY CREEK—54 SAMPLES [1]—Continued													
1966	DDE	11	—	—	—	T	T	12	T	—	—	—	T
	TDE	T	—	—	—	T	T	T	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	11	14	14	12	12	T	13	—	T	—	—	T
	TDE	T	12	14	11	15	T	14	—	—	—	—	—
	DDT	T	T	11	12	13	21	31	—	—	—	—	—
1968	DDE	T	T	T	13	12	—	—	T	—	—	—	—
	TDE	11	—	T	T	—	—	—	T	—	—	—	—
	DDT	T	—	—	—	—	—	—	T	—	—	—	—
1969	DDE	—	—	—	T	T	24	—	—	—	12	14	17
	TDE	—	—	—	—	—	23	—	—	—	13	T	13
	DDT	—	—	—	—	33	44	—	—	—	27	13	13
	Mirex	—	—	T	—	—	—	—	—	—	—	—	—
STATION 13.—ST. PIERRE CREEK—12 SAMPLES [1]													
1969	DDE	—	T	—	T	T	22	—	—	—	15	13	T
	TDE	—	—	—	—	—	21	—	—	—	15	T	—
	DDT	—	—	—	—	30	45	—	—	—	29	13	—
	Mirex	—	—	38	—	—	—	—	—	—	—	—	—
STATION 14.—WHALE BRANCH—41 SAMPLES [1]													
1965	DDE							T	T	—	T	T	T
	TDE							T	T	—	T	—	T
	DDT							T	T	—	—	—	T
1966	DDE	—	—	—	T	T	—	—	—		11	33	T
	TDE	—	—	—	T	—	—	—	—		11	20	—
	DDT	—	—	—	—	—	—	—	—		—	26	—
1967	DDE	13	T	—	11	T	—	T	—	11	—	—	—
	TDE	T	—	—	T	T	—	T	—	—	—	—	—
	DDT	T	—	—	T	—	—	T	—	T	—	—	—
1968	DDE	11	T	—	14	—	—	—	T	T	—	—	—
	TDE	T	T	—	14	—	—	—	12	—	—	—	—
	DDT	—	—	—	—	—	—	—	15	—	—	—	—
STATION 15.—SKULL CREEK—39 SAMPLES [1]													
1965	DDE							T	T		T	T	—
	TDE							T	T		T	—	—
	DDT							—	T		—	—	—

TABLE L-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—South Carolina*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 15.—SKULL CREEK—39 SAMPLES [1]—Continued													
1966	DDE	—	—	—	—	12	T	—	—	—	—	T	—
	TDE	—	—	—	—	12	T	—	—	—	—	T	—
	DDT	—	—	—	—	T	—	—	—	—	—	—	—
1967	DDE	—	—	—	11	—	T		—	—	—		—
	TDE	—	—	—	14	—	T		—	—	—		T
	DDT	—	—	—	T	—	16		—	—	—		T
1968	DDE	T	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	17	—	—
	Dieldrin	—	—	—	—	—	—	—	—	—	—	—	35
STATION 16.—MAY CREEK—12 SAMPLES [1]													
1969	DDE	—	—	—	15	T	—	—	T	—	—	—	—
	TDE	—	—	—	—	T	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	11	—	—	—	—	—	—	—	—
	Mirex	—	—	23	37	27	—	—	—	—	—	—	—
STATION 17.—NEW RIVER—12 SAMPLES [1]													
1969	DDE	—	—	—	T	—	—	—	—	—	—	—	—
	TDE	—	—	—	11	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	21	—	—	—	—	—	—	—	—
	Mirex	—	—	—	—	27	—	—	—	—	—	—	—

[1] Each sample represents 15 or more mature mollusks.

SECTION M.—TEXAS

The eastern oyster, *Crassostrea virginica*, was used to monitor pollution in Texas estuarine waters during the period July 1965 - June 1972. All samples were analyzed at the Gulf Breeze Laboratory. Approximate locations of the 13 sampling stations are shown in Fig. M-1. A summary of data on organochlorine residues in the monitored species, *C. virginica*, is presented in Table M-1, and the distribution of residues in this species for each sampling station by date of collection in Table M-2. In some instances, more than one reef was sampled at different times in a particular bay. In these instances, the data have been integrated to reflect bay conditions as a whole. At some times, floods resulting from tropical storms decimated oyster reefs and inerrupted routine monitoring. On at least one occasion, sample preparation reagents were contaminated with chlordane leading to spurious analytical results. Consequently, all findings of chlordane have been omitted from the data tabulations.

In conjunction with oyster monitoring in Texas, many samples of fish and other vertebrates were analyzed throughout the monitoring program. These analyses indicated, as might be expected, more kinds of pollutants and of greater magnitude than those found in oysters. PCB's, for example, were commonly found in fish samples but were detected in only five collections of oysters. In the Arroyo Colorado, Station 12, findings of consistently large DDT residues in oysters were paralleled by DDT residues about 10 times larger in fish. A causal relationship between DDT residues in the eggs and reproductive failure of the spotted sea trout, *Cynoscion nebulosus*, there in 1969, has been postulated (*5*).

Although the incidence of DDT residues was higher in eight other States, samples from monitoring stations in Texas bays that receive runoff from the agricultural areas were consistently contaminated with DDT. The maximum DDT residue detected, 1,249 ppb, was in an isolated sample; more typically the residues in contaminated areas were in the range of 100 - 500 ppb of DDT. Toxaphene of presumably agricultural origin was detected in only one sample.

There is a clearly defined trend of declining DDT residues in oysters. In 1971, there was a more than 50% increase in the number of samples containing negligible DDT residues (i.e., <11 ppb) over previous years and a 75% decrease in the number of samples in the 100 - 1,000 ppb range.

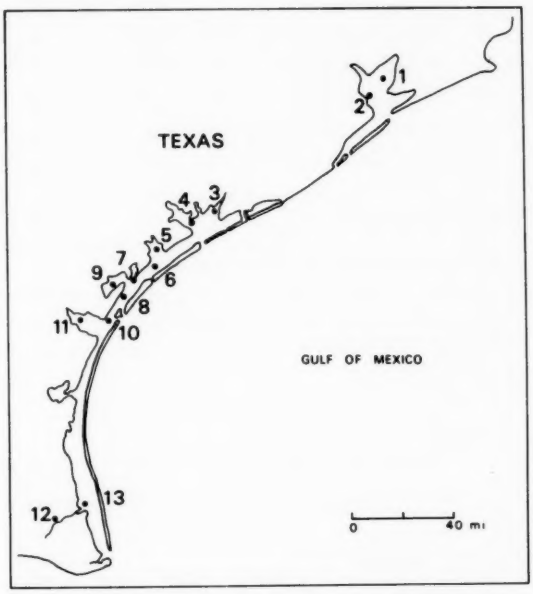

FIGURE M-1.—*Diagram of coastal Texas showing approximate location of monitoring stations*

1. Trinity Bay—Trinity-San Jacinto River basins
2. Galveston Bay—Trinity-San Jacinto River basins
3. Tres Palacios Bay—Lavaca River Basin
4. Lavaca Bay—Lavaca River Basin
5. San Antonio Bay, North—Guadalupe-San Antonio River Basin
6. San Antonio Bay, South—Guadalupe-San Antonio River Basin
7. St. Charles Bay—San Antonio-Nueces Coastal Area
8. Aransas Bay—San Antonio-Nueces Coastal Area
9. Copano Bay—San Antonio-Nueces Coastal Area
10. Red Fish Bay—San Antonio-Nueces Coastal Area
11. Nueces Bay—Nueces River Basin
12. Arroyo Colorado—Rio Grande Coastal Area
13. Lower Laguna Madre—Rio Grande Coastal Area

TABLE M-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-72—Texas*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µG/KG)							
				DDT		Dieldrin		Endrin		Toxaphene [2]	PCB's [3]
1	Trinity Bay	1965-69	47	28	(51)	1	(20)				
2	Galveston Bay	1965-72	71	60	(88)	31	(87)				
3	Tres Palacios Bay	1965-72	74	71	(974)	6	(18)				
4	Lavaca Bay	1965-72	66	59	(400)	4	(24)				2
5	San Antonio Bay, North	1965-72	59	38	(78)	8	(27)				
6	San Antonio Bay, South	1965-72	75	40	(488)	3	(56)	1	(10)		

TABLE M-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-72—Texas*—Continued

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)									
				DDT		Dieldrin		Endrin		Toxaphene [2]	PCB's [2]		
7	St Charles Bay	1966-72	66	33	(93)	11	(80)						
8	Aransas Bay	1965-67	19	18	(83)	2	(48)						
9	Copano Bay	1967-71	51	24	(96)								
10	Red Fish Bay	1966-72	67	52	(82)						2		
11	Nueces Bay	1965-68	20	20	(450)	4	(33)	3	(18)				
12	Arroyo Colorado	1965-71	48	48	(710)	45	(46)	18	(32)	1			
13	Lower Laguna Madre	1965-67	24	15	(57)	1	(46)						
	Occasional stations (16)	1965-72	41	24	(1,249)	16	(64)				1		
Total number of samples			728										
Percent of samples positive for indicated compound				73		18		3			<1		

[1] Each sample represents 15 or more mature mollusks.
[2] Present but not quantified.

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*

[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB s); T = >5 but <10 ppb.]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—TRINITY BAY—47 SAMPLES [1]													
1965	DDE							T	—	T	T	T	11
	TDE							T	—	—	T	10	16
	DDT							—	—	—	—	—	—
1966	DDE	12	18	15		18	—	—	—	—	—	T	T
	TDE	17	27	28		33	—	—	—	—	—	T	12
	DDT	—	—	—		—	—	—	—	—	—	—	—
1967	DDE	T	T	12	—	—	T	—	—	—	T	T	T
	TDE	T	12	18	—	—	T	—	—	—	T	T	—
	DDT	—	—	—	—	—	T	—	—	—	T	—	—
1968	DDE	T	T	T	T	T	—	—	T	—	10	T	
	TDE	11	T	T	11	T	—	—	—	—	T	—	
	DDT	—	—	—	—	—	—	—	—	—	—	—	
1969	DDE		—			T	—	—	—	—			T
	TDE		—			13	—	—	—	—			—
	DDT		—			—	—	—	—	—			—
	Dieldrin		—			20	—	—	—	—			—

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—GALVESTON BAY—71 SAMPLES[1]													
1965	DDE							—	T	T		T	T
	TDE							—	—	—		11	17
	DDT							—	—	—		—	—
1966	DDE	15	18	13		11	—	—	—	—	T	T	T
	TDE	36	43	32		33	—	—	—	—	T	24	24
	DDT	T	—	—		—	—	—	—	—	—	—	—
	Dieldrin	—	—	—		—	—	—	—	—	—	12	—
1967	DDE	T	11	15	13	—	T	—	T	T	11	11	13
	TDE	26	29	44	34	15	18	—	10	T	21	23	32
	DDT	T	—	—	—	—	—	—	—	—	11	—	—
	Dieldrin	12	14	15	—	—	—	—	—	—	—	14	19
1968	DDE	10	16	T	14	20	T	T	T	T	14	T	—
	TDE	24	43	36	37	46	41	30	13	15	46	34	49
	DDT	—	T	—	—	—	—	—	—	—	13	—	—
	Dieldrin	13	25	20	—	—	—	—	—	—	—	19	14
1969	DDE		T			24	—	T	10	—			19
	TDE		44			64	23	13	11	T			19
	DDT		—			—	—	—	—	—			—
	Dieldrin		30			19	—	—	—	—			—
1970	DDE		13	15	T	12	T	—	—	—	—	11	—
	TDE		35	34	34	32	18	20	—	—	17	31	32
	DDT		—	10	T	—	—	—	—	—	—	—	—
	Dieldrin		18	19	11	14	—	—	—	13	—	24	18
1971	DDE	T	11		—				—	—	—	T	T
	TDE	39	38		48				—	—	—	17	17
	DDT	—	—		—				—	—	—	T	11
	Dieldrin	16	23		30				65	46	—	—	26
1972	DDE	T	T	T	T	—							
	TDE	18	T	26	15	T							
	DDT	—	—	—	—	—							
	Dieldrin	42	26	87	24	36							
STATION 3.—TRES PALACIOS BAY—74 SAMPLES[1]													
1965	DDE							11	11	T	T	21	93
	TDE							T	T	—	—	T	29
	DDT							—	—	—	—	T	65

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 3.—TRES PALACIOS BAY—74 SAMPLES [1]—Continued													
1966	DDE	78	78	250	190	300	47	210	97	21	11	23	26
	TDE	36	36	44	53	89	22	97	29	T	—	T	T
	DDT	43	53	80	59	130	12	23	—	—	—	—	—
1967	DDE	42	42	67	51	34	58	18	12	18	72	150	240
	TDE	14	17	31	19	14	24	—	—	—	41	52	57
	DDT	—	T	11	T	15	11	—	—	—	T	71	38
1968	DDE	270	220	230	320	300	91	62	43	20	19	22	24
	TDE	66	57	23	590	77	62	95	10	42	13	19	15
	DDT	83	21	81	64	22	T	17	—	T	—	—	—
	Dieldrin	—	18	—	—	—	—	—	—	—	—	—	—
1969	DDE	25	24	83		91	55	95	58	43			25
	TDE	19	18	35		44	62	15	56	T			40
	DDT	—	T	27		21	15	—	—	—			12
	Dieldrin	—	—	—		—	—	—	—	10			—
1970	DDE	70	36	110	230		44	33	41	—	50		16
	TDE	48	29	51	44		38	55	72	—	—		12
	DDT	31	—	19	56		31	—	—	—	—		—
	Dieldrin	—	13	17	13		—	—	—	—	—		—
1971	DDE	—	43	14	13		10	13	15	T	—	14	T
	TDE	—	30	12	12		23	27	44	—	—	15	T
	DDT	—	—	—	—		—	—	—	—	—	—	—
1972	DDE	100	59										
	TDE	25	20										
	DDT	15	T										
	Dieldrin	—	T										
STATION 4.—LAVACA BAY—66 SAMPLES [1]													
1965	DDE								T	—	T	13	22
	TDE								—	—	—	T	T
	DDT								—	—	—	T	10
1966	DDE	33	40	43	56	51	140	39	26	17	T	T	11
	TDE	12	17	T	27	25	30	16	11	—	—	—	—
	DDT	11	18	T	16	21	23	—	—	—	—	—	—
1967	DDE	22	16	20	25	14	T	25	14	14	T	19	26
	TDE	13	T	12	14	T	—	13	—	—	—	—	12
	DDT	—	—	—	T	14	—	34	—	—	—	—	T

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 4.—LAVACA BAY—66 SAMPLES [1]—Continued													
1968	DDE	39	38	39	69	46	140						24
	TDE	16	17	22	62	39	120						13
	DDT	26	40	18	49	34	140						—
	Dieldrin	—	—	—	—	—	24						—
1969	DDE	20	19	33		41	33	—	12	—	26		40
	TDE	T	—	11		19	22	—	—	—	18		33
	DDT	—	—	—		14	16	—	—	—	15		48
1970	DDE	—	120		30	[2]		37	[2]	—	—		16
	TDE	—	42		16	[2]		53	[2]	—	—		T
	DDT	—	26		11	[2]		—	[2]	—	—		—
	Dieldrin	—	—		10	—		—	—	—	—		—
	PCB's	—	—		—	[2]		—	[2]	—	—		—
1971	DDE	48		43	43	22	T	T	—		12	T	13
	TDE	29		15	—	—	—	—	—		25	—	—
	DDT	T		—	—	—	—	—	—		—	—	—
	Dieldrin	—		—	—	—	—	—	—		—	—	14
1972	DDE	18											
	TDE	T											
	DDT	T											
	Dieldrin	21											
STATION 5.—SAN ANTONIO BAY (NORTH)—59 SAMPLES [1]													
1965	DDE							T	T	T	T	11	30
	TDE							T	T	T	T	T	25
	DDT							—	T	—	T	T	16
	Dieldrin							—	—	—	—	—	11
1966	DDE	31	30	32	29	33	29	16	—	T	13	15	19
	TDE	24	27	30	23	27	22	10	—	—	—	T	14
	DDT	14	16	15	—	18	13	—	—	—	—	—	—
	Dieldrin	—	—	17	—	—	—	—	—	—	—	—	—
1967	DDE	17	20	22	29	13	12	T	—	11	14		
	TDE	13	18	18	30	T	—	—	—	T	13		
	DDT	—	—	—	T	—	—	—	—	14	—		
	Dieldrin	—	10	—	—	—	—	—	—	—	—		
1968		No Samples Collected											
1969	DDE							—	—	—	T		18
	TDE							—	—	—	T		12
	DDT							—	—	—	—		T

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—SAN ANTONIO BAY (NORTH)—59 SAMPLES [1]—Continued													
1970	DDE	—	—	18	14	17	—	—	—	—	—	—	—
	TDE	—	—	—	—	33	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	—	—	—	27	—	—	—	17	—
1971	DDE	T	—	—		—	—	—	—	10	—	T	13
	TDE	12	—	—		—	—	—	—	—	—	11	—
	DDT	—	—	—		—	—	—	—	19	—	—	—
	Dieldrin	—	—	—		—	—	—	—	—	—	12	17
1972	DDE	12	12			T							
	TDE	—	—			—							
	DDT	—	—			—							
	Dieldrin	T	—			—							
STATION 6.—SAN ANTONIO BAY (SOUTH)—75 SAMPLES [1]													
1965	DDE							—	T	T	T	12	17
	TDE							—	—	T	T	10	T
	DDT							—	—	T	T	T	T
1966	DDE	13	13	14	19	14	T	—	—	—	T	15	10
	TDE	T	—	—	14	10	—	—	—	—	—	T	T
	DDT	T	—	—	—	10	—	—	—	—	—	T	—
1967	DDE	17	20	20	14	T	—	—	—	T			
	TDE	11	10	11	—	—	—	—	—	T			
	DDT	10	—	11	—	—	—	—	—	T			
1968	DDE				21	T	—	—	110	—	—	—	T
	TDE				19	—	—	—	310	—	—	—	T
	DDT				13	—	—	—	68	—	—	—	—
	Dieldrin				56	—	—	—	14	—	—	—	—
	Endrin				10	—	—	—	—	—	—	—	—
1969	DDE	T	16	20	16	T	—		—	—	T	T	12
	TDE	—	—	—	14	T	—		—	—	T	T	15
	DDT	—	—	—	T	—	—		—	—	—	—	T
	Dieldrin	14	—	—	—	—	—		—	—	—	—	—
1970	DDE	—	—	—	—	11	—	—	—	—	—	13	—
	TDE	—	—	—	—	25	—	—	—	—	—	41	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1971	DDE	—	—	—	—	T	—	—	—	—	—	T	13
	TDE	—	—	—	—	—	—	—	—	—	—	—	10
	DDT	—	—	—	—	—	—	—	—	—	—	—	T

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 6.—SAN ANTONIO BAY (SOUTH)—75 SAMPLES[1]—Continued													
1972	DDE	13	16			T							
	TDE	—	—			—							
	DDT	—	—			—							
STATION 7.—ST. CHARLES BAY—66 SAMPLES[1]													
1966	DDE	11	T	11		11	—	—	—	—	T	T	15
	TDE	—	—	—		—	—	—	—	—	—	—	T
	DDT	—	—	—		T	—	—	—	—	—	—	T
	Dieldrin	—	—	—		—	—	—	—	—	—	—	11
1967	DDE	15	20	17	23	16	—	—	—	12	15	16	17
	TDE	T	T	T	52	47	—	—	—	—	—	T	12
	DDT	T	T	—	—	23	—	—	—	—	—	—	10
	Dieldrin	13	12	—	28	39	78	80	—	—	—	—	15
1968[4]	DDE	22	30	—	24	19	—	T	—	—	—	—	—
	TDE	—	20	—	19	16	—	—	—	—	—	—	—
	DDT	—	43	—	11	23	—	—	—	—	—	—	—
1969	DDE	—	—	14	12	T	T	—	—	—	—	—	T
	TDE	—	—	T	21	17	15	—	—	—	—	—	—
	DDT	—	—	—	—	T	—	—	—	—	—	—	—
	Dieldrin	49	—	—	—	—	—	27	—	T	—	—	—
1970	DDE							—	—		—	—	—
	TDE							—	—		—	—	—
	DDT							—	—		—	—	—
1971[4]	DDE	—	—	—	—	—	—	—		T	T		13
	TDE	—	—	—	—	—	—	—		T	T		T
	DDT	—	—	—	—	—	—	—		21	10		15
1972[4]	DDE	14	23	27	16								
	TDE	T	T	10	—								
	DDT	14	15	—	—								
STATION 8.—ARANSAS BAY—19 SAMPLES[1]													
1965	DDE								T	21			
	TDE								T	T			
	DDT								—	—			
1966	DDE	12	16	20	16	16	10	T	T	T	27	15	15
	TDE	T	45	57	—	43	35	30	33	20	26	42	43
	DDT	T	—	T	—	14	—	—	—	—	—	—	T

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 8.—ARANSAS BAY—19 SAMPLES [1]—Continued													
1967	DDE	23	24	27	—	T							
	TDE	54	49	56	—	—							
	DDT	T	T	—	—	—							
	Dieldrin	—	—	—	28	48							
STATION 9.—COPANO BAY—51 SAMPLES [1, 4]													
1967	DDE						—	—	—	—	T	—	21
	TDE						—	—	96	—	20	—	30
	DDT						—	—	—	—	—	—	T
1968	DDE	14	18	—	21	T	12	T	—	—	—	—	—
	TDE	23	28	—	24	—	—	—	—	—	—	—	—
	DDT	—	—	—	T	—	—	—	—	—	—	—	—
1969	DDE	—	T	—	50	15	17	—	—	—	—	—	15
	TDE	T	—	—	21	27	23	—	—	—	—	—	T
	DDT	—	—	—	T	18	T	—	—	—	—	—	T
1970	DDE	17	15	25	14	—	—	—	—	—	—	—	—
	TDE	11	T	T	14	—	—	—	—	—	—	—	—
	DDT	T	T	—	T	—	—	—	—	—	—	—	—
1971	DDE	10	13	15	17	10	—	—	—				
	TDE	10	11	10	39	10	—	—	—				
	DDT	—	—	—	—	—	—	—	—				
STATION 10.—RED FISH BAY—67 SAMPLES [1, 4]													
1966	DDE					29		24	12	T	T	T	T
	TDE					25		21	18	T	11	T	T
	DDT					12		12	—	—	—	—	—
1967	DDE	T	15	17	—	T	14	T	—				
	TDE	T	21	32	—	14	39	19	—				
	DDT	—	T	T	—	—	13	14	—				
1968	DDE		23	25	18		12	10	10	11	—	—	10
	TDE		14	26	43		18	21	18	15	21	—	17
	DDT		—	12	21		—	—	T	23	T	—	T
1969	DDE	15	T	10	15	—	T	—	—	12	—	11	17
	TDE	27	T	19	27	18	T	—	—	—	—	15	22
	DDT	13	—	T	19	—	—	—	—	—	—	T	13

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 10.—RED FISH BAY—67 SAMPLES [1]—Continued													
1970	DDE	16	14	18	17	10	12	14	12	—	—	—	T
	TDE	20	19	29	25	23	38	25	18	—	—	—	29
	DDT	T	10	13	12	—	—	—	10	—	—	—	15
	PCB's	—	—	—	—	—	—	—	—	—	[2]	—	—
1971	DDE	—	—	17	—	T	—	—	13	T	T	T	12
	TDE	—	—	14	—	—	—	—	13	—	T	T	11
	DDE	—	—	—	—	—	—	—	17	26	17	22	26
1972	DDE	14	20	16	18	—	T						
	TDE	11	15	16	12	—	14						
	DDT	22	30	45	42	—	34						
	PCB's	—	—	—	—	—	[2]						
STATION 11.—NUECES BAY—20 SAMPLES [1]													
1965	DDE									T			
	TDE									—			
	DDT									—			
1966	DDE			34	22	32		120	18	18	T	T	
	TDE			30	17	26		200	20	16	—	12	
	DDT			12	—	14		130	—	—	—	—	
	Dieldrin			—	—	—		33	—	—	—	—	
1967	DDE	31	30	43	46	34	29	20	32	57	51		
	TDE	36	61	110	110	48	52	20	20	25	22		
	DDT	T	22	20	26	22	49	17	37	35	15		
	Dieldrin	—	11	13	19	—	—	—	—	—	—		
	Endrin	—	18	12	11	—	—	—	—	—	—		
1968	DDE			45									
	TDE			28									
	DDT			15									
STATION 12.—ARROYO COLORADO—48 SAMPLES [1]													
1965	DDE									170	24	55	64
	TDE									520	33	80	80
	DDT									20	T	17	16
	Dieldrin									19	T	29	34
	Endrin									—	—	32	19
1966	DDE	80	120	120	74	96	230	300	270	98	12	180	63
	TDE	110	140	130	70	69	140	230	93	57	—	50	58
	DDT	21	19	17	—	26	31	53	24	—	—	19	12
	Dieldrin	32	23	24	18	16	30	45	27	14	—	18	20
	Endrin	18	17	14	—	22	23	28	13	—	—	14	12

TABLE M-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Texas*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 12.—ARROYO COLORADO—48 SAMPLES [1]—Continued													
1967	DDE	120	140	210	170	110	160	160	79				
	TDE	73	110	180	75	49	63	92	49				
	DDT	27	—	28	19	26	24	23	16				
	Dieldrin	23	16	42	46	19	33	30	16				
	Endrin	11	29	19	—	—	—	12	—				
1968	DDE			48								160	
	TDE			150								68	
	DDT			—								49	
	Dieldrin			—								33	
1969	DDE	260	330	220	320	180	260	280	86	100	110	210	54
	TDE	110	100	48	100	35	63	55	28	33	30	T	21
	DDT	15	57	35	110	77	48	22	—	—	T	—	24
	Dieldrin	14	16	17	18	14	25	18	17	12	T	16	—
1970	DDE	23	120	140	110	130	96						
	TDE	35	20	25	29	25	54						
	DDT	32	19	22	T	T	60						
	Dieldrin	21	18	23	25	13	25						
	Endrin	T	T	—	—	—	12						
1971	DDE				65	280	380	220					
	TDE				14	61	46	78					
	DDT				—	—	—	—					
	Dieldrin				11	27	24	38					
	Toxaphene				—	—	—	[3]					
STATION 13.—LOWER LAGUNA MADRE—24 SAMPLES [1]													
1965	DDE									T	T	—	—
	TDE									—	—	—	—
	DDT									—	—	—	—
1966	DDE	—	—	—	—	27	T	T	13	—	12	—	T
	TDE	—	—	—	—	19	—	—	—	—	—	—	—
	DDT	—	—	—	—	11	—	—	—	—	—	—	—
	Dieldrin	—	—	—	—	—	46	—	—	—	—	—	—
1967	DDE	11	15	13	13	10	12	T	—				
	TDE	—	—	—	—	—	T	—	—				
	DDT	—	—	—	—	14	T	—	—				

[1] Each sample represents 15 or more mature mollusks.
[2] DDT present but not quantified due to presence of PCB's in sample.
[3] Present but not quantified.
[4] Dieldrin data omitted because of possible sample contamination.

SECTION N.—VIRGINIA

The eastern oyster, *Crassostrea virginica,* was monitored at 10 principal stations in estuarine areas of Virginia during the period July 1965 - February 1972. Samples were analyzed at the Gulf Breeze Laboratory until June 1968, and thereafter at the Virginia Institute of Marine Science. The approximate station locations are shown in Fig. N-1. A summary of data on organochlorine residues in the monitored species, *C. virginica,* is presented in Table N-1, and the distribution of residues in this species for each sampling station by data of collection in Table N-2.

The 87% incidence of DDT residues in Virginia samples and the maximum residue of 678 ppb were fourth highest of the States monitored. The higher residues were clearly associated with intensive truck farming (Station 2) and a combination of urban and industrial development (Station 9).

The presence of PCB's was noted in 1970 samples, but not until 1971 was equipment acquired to identify and quantify these compounds. The residue of 2,800 ppb of Aroclor 1254® detected in oysters in the Elizabeth River, a highly industrialized area, has prompted a special study to pinpoint the source of this pollution.

Trends in DDT residues in Virginia oysters differ somewhat from other areas in that, while the larger residues (those above 100 ppb) decreased by 66% in 1971, 100% of the 1971 samples contained residues in excess of 11 ppb as compared to 82% in earlier years. It appears that DDT residues are more widely dispersed but at relatively lower levels, presumably through the processes of recycling.

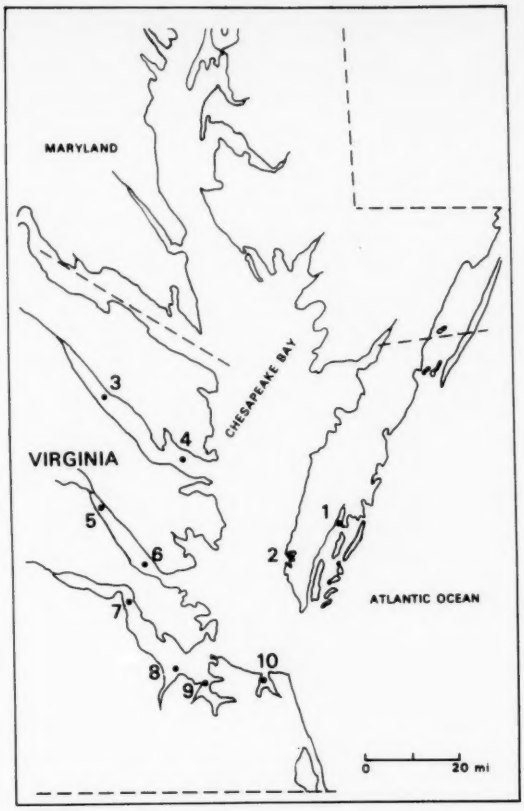

FIGURE N-1.—*Diagram of coastal Virginia showing approximate location of monitoring stations*

1. Machipongo River
2. Cherrystone Inlet—Chesapeake Bay
3. Bowlers Rock—Rappahannock River
4. Urbanna—Rappahannock River
5. Bell Rock—York River
6. Pages Rock—York River
7. Deep Water Shoals—James River
8. Nansemond Ridge—James River
9. Hospital Point—Elizabeth River
10. Lynnhaven Bay

TABLE N-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-72—Virginia*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μG/KG)		
				DDT	Dieldrin	PCB's [2]
1	Machipongo River	1965-72	67	56 (127)	2 (11)	1 (390)
2	Cherrystone Inlet	1965-72	68	67 (678)		2 (510)
3	Bowlers Rock	1965-72	70	62 (60)		2 (400)
4	Urbana	1965-72	69	59 (45)		2 (270)
5	Bell Rock	1965-72	69	35 (54)		2 (450)
6	Pages Rock	1965-72	68	50 (100)	1 (T)	2 (400)
7	Deep Water Shoals	1965-72	69	69 (144)	38 (40)	3 (1,000)

TABLE N-1.—*Summary of data on organochlorine residues in the monitored species* (C. virginica), *1965-72—Virginia*—Continued

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µg/kg)					
				DDT		Dieldrin		PCB's [2]	
8	Nansemond Ridge	1965-72	64	63	(128)	29	(22)	2	(1,000)
9	Hospital Point	1966-72	58	58	(300)	38	(24)	3	(2,800)
10	Lynnhaven Bay	1965-70	62	61	(113)	4	(16)		
	Occasional stations (4)	1965-67	5	5	(241)				
Total number of samples			669						
Percent positive for indicated compound				87		17		3	

NOTE: T = >5 but < 10 ppb.
[1] Each sample represents 15 or more mature mollusks.

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*
[Blank = no sample collected; — = no residue detected above 5 ppb or no residue detected (PCB's); T = >5 but <10 ppb]

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—MACHIPONGO RIVER—67 SAMPLES [1]													
1965	DDE							34	15	18	T	13	15
	TDE							20	13	28	T	T	T
	DDT							73	T	24	—	—	—
	Dieldrin							11	—	—	—	—	—
1966	DDE	12	T	11	14	19	17	19	—	T	T	—	T
	TDE	—	—	—	T	14	18	17	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	34	T	T	17	14	T	T	—	—	T	11
	TDE	—	59	—	—	12	13	—	T	—	—	—	—
	DDT	—	10	—	—	—	T	—	T	—	—	—	—
1968	DDE	T	—	T	—	T	18	15	T	—	T	11	T
	TDE	—	—	—	—	—	10	20	T	—	T	T	—
	DDT	—	—	—	—	—	—	10	—	—	—	—	—
1969	DDE	T	T	T	T	T	13	—	11		T	20	T
	TDE	—	T	—	—	T	13	—	16		T	27	T
	DDT	—	T	—	—	—	T	—	—		—	16	—
	Dieldrin	—	—	—	—	—	—	—	—		T	—	—
1970	DDE	15	10	—	—	11	24		T	T	T	11	
	TDE	14	T	—	—	T	35		13	T	T	T	
	DDT	—	11	—	—	—	17		T	—	—	—	
1971	DDE						10		18		17		
	TDE						—		T		T		
	DDT						—		—		—		
	PCB's						—		—		[2] 390		

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—MACHIPONGO RIVER—67 SAMPLES [1]—Continued													
1972	DDE		12										
	TDE		—										
	DDT		—										
STATION 2.—CHERRYSTONE INLET—68 SAMPLES [1]													
1965	DDE							60	35	16	24	25	45
	TDE							89	60	14	42	32	55
	DDT							230	71	T	35	20	35
1966	DDE	45	42	33	43	36	32	90	41	14	25	19	36
	TDE	49	46	45	40	36	37	110	86	35	66	62	73
	DDT	23	26	25	15	11	16	130	59	T	20	11	14
1967	DDE	49	31	32	37	45	37	34	44	55	26	24	20
	TDE	74	52	36	53	75	68	61	63	81	42	29	18
	DDT	17	14	—	12	10	21	110	110	120	22	13	T
1968	DDE	19	27	35	59	42	40	146	63	20	33	33	T
	TDE	18	20	46	58	55	52	210	172	76	31	31	15
	DDT	T	—	T	21	12	17	322	42	12	T	T	T
1969	DDE	24	11	21	17	12	T	15	35	17	24	16	35
	TDE	16	14	22	16	13	14	10	31	22	34	10	39
	DDT	—	—	—	—	—	—	—	20	11	13	—	17
1970	DDE	32	33	—	20	28			24	T	22	18	19
	TDE	30	42	—	21	29			26	T	34	19	22
	DDT	T	16	—	—	—			23	T	T	—	T
1971	DDE						30		22		29		
	TDE						30		14		23		
	DDT						—		14		T		
	PCB's						—		—		[2] 350		
1972	DDE		43										
	TDE		18										
	DDT		—										
	PCB's		[3] 510										
STATION 3.—BOWLERS ROCK—70 SAMPLES [1]													
1965	DDE							16	T	T	T	T	11
	TDE							23	T	T	T	T	12
	DDT							21	T	T	T	—	—
1966	DDE	11	10	—	13	11	13	13	T	—	—	T	—
	TDE	T	T	—	T	11	15	15	T	—	—	T	—
	DDT	—	—	—	—	—	T	—	—	—	—	—	—

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 3.—BOWLERS ROCK—70 SAMPLES[1]—Continued													
1967	DDE	—	T	T	10	T	T	10	—	—	T	T	T
	TDE	—	—	T	11	T	11	14	15	—	T	T	T
	DDT	—	—	—	—	—	—	11	18	—	T	T	—
1968	DDE	—	T	T	T	T	13	10	10	—	17	T	12
	TDE	—	—	T	—	—	14	12	15	—	17	T	T
	DDT	—	—	—	—	—	—	—	T	—	T	—	—
1969	DDE	T	T	11	12	10	T	T	T	T	11	T	11
	TDE	10	T	10	14	10	T	T	T	10	18	14	13
	DDT	—	—	—	—	T	—	—	T	T	14	T	T
1970	DDE	16	10	T	T	10	10	T	T	—	T	—	T
	TDE	14	T	—	11	10	17	12	T	T	12	T	T
	DDT	T	32	—	—	—	T	—	—	T	T	—	—
1971	DDE					11				T			14
	TDE					T				—			12
	DDT					—				—			—
	[2] PCB's					T				—			400
1972	DDE		17										
	TDE		12										
	DDT		—										
STATION 4.—URBANA—69 SAMPLES[1]													
1965	DDE							T	10	T	T	T	13
	TDE							13	16	T	—	—	10
	DDT							14	19	T	—	—	—
1966	DDE	10	T	—	—	10	T	15	—	T	—	—	T
	TDE	T	—	—	—	—	—	—	—	—	—	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	T
1967	DDE	12	10	11	T	T	T	T	T	—	T	11	11
	TDE	—	T	T	T	T	T	T	T	—	11	T	12
	DDT	—	—	—	—	—	—	—	T	—	12	—	T
1968	DDE	T	T	T	11	T	11	14	T	—	T	T	T
	TDE	T	—	T	T	—	—	13	T	—	T	12	T
	DDT	—	—	—	—	—	—	T	—	—	—	T	—
1969	DDE	T	T	—	T	T	T	T	T	T	11	T	T
	TDE	T	11	—	—	T	T	T	13	T	18	10	10
	DDT	T	T	—	—	—	—	—	—	—	16	—	—
1970	DDE		T	—	T	10	15	T	—	10	—	T	T
	TDE		10	—	T	T	17	T	T	17	—	T	T
	DDT		16	—	—	—	T	T	—	14	—	—	T

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
		STATION 4.—URBANA—69 SAMPLES [1]—Continued											
1971	DDE					10				T		10	
	TDE					T				—		T	
	DDT					—				—		—	
	[3] PCB's					T				—		270	
1972	DDE		10										
	TDE		T										
	DDT		—										
		STATION 5.—BELL ROCK—69 SAMPLES [1]											
1965	DDE							11	T	T	T	11	16
	TDE							24	T	13	10	13	21
	DDT							19	T	10	T	—	13
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	T
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	T	—	T	—	—	—	—	—	—	—	T
	TDE	—	T	—	—	—	—	—	—	—	12	—	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	T	T	—	T	T	11
	TDE	—	—	—	—	—	—	10	T	—	T	T	T
	DDT	—	—	—	—	—	—	—	—	—	—	—	11
1969	DDE	—	—	—	—	—	T	—	T	T	11		17
	TDE	—	—	—	—	—	T	—	T	14	20		T
	DDT	—	—	—	—	—	—	—	—	—	10		—
1970	DDE	T	T	—	T	T	10	10	—	—	—	—	T
	TDE	T	12	11	11	T	18	13	T	T	—	—	T
	DDT	—	—	—	—	—	—	T	—	—	—	—	—
1971	DDE					T				—		T	
	TDE					—				T		T	
	DDT					—				—		—	
	PCB's					—				—		[2] 390	
1972	DDE		T										
	TDE		T										
	DDT		—										
	PCB's		[2] 450										
		STATION 6.—PAGES ROCK—68 SAMPLES [1]											
1965	DDE							10	T	11	11	17	19
	TDE							15	12	17	14	20	16
	DDT							17	14	14	12	24	13

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 6.—PAGES ROCK—68 SAMPLES [1]—Continued													
1966	DDE	14	—	—	T	10	11	—	T	—	T	—	T
	TDE	13	—	—	—	T	11	—	T	—	T	—	T
	DDT	T	—	—	—	—	—	—	11	—	—	—	—
1967	DDE	—	—	T	10	—	T	T	—	T	T	T	13
	TDE	—	—	—	T	—	T	T	—	16	14	11	14
	DDT	—	—	—	—	—	—	—	T	14	T	—	—
1968	DDE	T	T	—	T	—	12	13	T	—	T	T	10
	TDE	—	T	—	—	—	—	14	10	—	10	T	11
	DDT	—	—	—	—	—	—	—	—	—	—	—	T
1969	DDE	—	—	T	—	T	13	—		14	18		T
	TDE	—	—	T	—	T	T	—		12	16		T
	DDT	—	—	T	—	—	—	—		T	T		—
	Dieldrin	—	—	—	—	—	—	—		—	T		—
1970	DDE	—	T	—	T	T	T	T	T	—	10	90	T
	TDE	T	20	—	T	T	29	12	T	—	T	10	T
	DDT	—	—	—	—	—	11	T	—	—	—	—	—
1971	DDE					T				—			T
	TDE					—				—			T
	DDT					—				—			—
	PCB's					[2] T				—			[3] 400
1972	DDE		T										
	TDE		T										
	DDT		—										
STATION 7.—DEEP WATER SHOALS—69 SAMPLES [1]													
1965	DDE							21	18	10	13	30	40
	TDE							52	31	17	22	41	56
	DDT							63	35	T	13	17	23
	Dieldrin							14	T	—	—	11	13
1966	DDE	37	11	24	26	30	40	37	23	11	18	19	17
	TDE	43	15	24	32	45	63	57	41	21	29	28	32
	DDT	15	—	—	—	14	20	30	22	T	16	15	10
	Dieldrin	—	—	—	23	34	38	16	17	—	12	—	—
1967	DDE	21	26	19	31	19	20	20	T	17	13	21	19
	TDE	29	30	21	41	25	32	37	25	33	20	23	20
	DDT	12	13	—	19	13	12	18	24	28	10	11	24
	Dieldrin	—	14	—	40	28	21	22	11	12	—	—	—
1968	DDE	15	14	17	15	15	23	18	14	T	15	12	19
	TDE	15	12	15	15	19	29	26	25	T	20	T	18
	DDT	—	—	—	—	11	14	15	18	—	T	T	T
	Dieldrin	—	—	12	12	16	16	T	T	—	—	T	—

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (µg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 7.—DEEP WATER SHOALS—69 SAMPLES [1]—Continued													
1969	DDE	T	T	10	11	T	10	18	14	17	20	28	
	TDE	10	T	12	T	T	16	12	16	23	28	40	
	DDT	—	—	—	—	T	T	—	16	21	20	29	
	Dieldrin	—	Lost	—	—	T	11	13	T	—	T	14	
1970	DDE	41	19	10	27	10	12	T	40	20	25	12	17
	TDE	43	22	11	12	T	21	22	71	40	43	17	28
	DDT	60	—	T	—	—	17	T	10	14	25	T	12
	Dieldrin	T	—	14	—	—	12	16	—	—	—	—	—
1971	DDE					40				T		16	
	TDE					35				13		21	
	DDT					T				—		—	
	Dieldrin					31				T		17	
	[2] PCB's					1,000				—		560	
1972	DDE		15										
	TDE		15										
	DDT		—										
	Dieldrin		10										
	PCB's		[2] 760										
STATION 8.—NANSEMOND RIDGE—64 SAMPLES [1]													
1965	DDE							16	17	17	T	27	36
	TDE							59	43	29	14	37	49
	DDT							53	39	25	T	24	31
	Dieldrin							17	T	—	—	T	11
1966	DDE	28	14	16	30	30	36		34	13	10	11	11
	TDE	35	14	17	34	29	52		55	18	15	16	19
	DDT	15	—	—	13	13	29		29	—	10	16	10
	Dieldrin	—	—	—	17	14	22		14	—	—	—	—
1967	DDE	14	17	22	18	15	14	14	18	T	13	17	20
	TDE	17	16	20	18	17	20	24	35	16	24	24	25
	DDT	T	T	11	T	T	12	11	20	T	10	13	10
	Dieldrin	—	—	—	15	12	T	12	14	—	—	10	11
1968	DDE	12	15	14	12	32	24	23	14	—	T	16	16
	TDE	14	16	15	12	47	32	38	29	—	12	13	22
	DDT	—	T	T	—	45	27	23	15	—	—	T	T
	Dieldrin	—	11	—	10	21	15	T	—	—	—	—	—
1969	DDE	—	T	10	T	T	11	T	50	11	16		16
	TDE	T	T	11	T	T	23	T	37	14	28		26
	DDT	—	—	—	—	—	10	—	23	T	13		12
	Dieldrin	—	—	—	—	—	10	—	—	—	11		T

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 8.—NANSEMOND RIDGE—64 SAMPLES [1]—Continued													
1970	DDE	12	15	—				10	16	10	T		T
	TDE	18	40	13				27	23	14	12		14
	DDT	22	11	35				—	13	11	10		T
	Dieldrin	T	—	T				T	—	—	—		—
1971	DDE					22				11			16
	TDE					18				13			15
	DDT					T				—			—
	Dieldrin					15				T			20
	PCB's					[3] 1,000				—			[3] 440
1972	DDE		16										
	TDE		14										
	DDT		—										
	Dieldrin		—										
STATION 9.—HOSPITAL POINT—58 SAMPLES [1]													
1966	DDE			140	82	63	83	66	37	20	24	26	27
	TDE			120	73	60	130	96	63	36	53	42	40
	DDT			40	32	31	89	39	43	22	35	27	24
	Dieldrin			13	18	15	20	—	—	—	—	—	T
1967	DDE	42	52	26	34	33	37	29	11	20	39	43	54
	TDE	48	53	17	25	42	76	67	55	59	83	78	64
	DDT	31	29	T	—	20	58	36	31	62	63	100	37
	Dieldrin	T	16	—	—	11	16	—	—	10	15	16	19
1968	DDE	68	92	60	57	48	50	30	20	14	13	11	26
	TDE	79	67	48	49	48	93	67	62	30	24	17	21
	DDT	52	55	18	20	34	83	35	19	12	10	T	T
	Dieldrin	13	19	15	12	12	13	10	T	—	10	11	—
1969	DDE	12	17	31	22	15	15	15	28	33	32		29
	TDE	T	11	32	21	28	28	33	70	84	92		56
	DDT	—	—	11	19	11	27	15	41	46	71		36
	Dieldrin	—	T	10	10	T	T	10	T	19	10		T
1970	DDE	15	32	15				T	18	24	13	T	15
	TDE	21	54	35				22	37	57	30	13	23
	DDT	T	29	—				10	19	28	14	—	11
	Dieldrin	T	14	—				—	—	—	—	—	—
1971	DDE					40				27			27
	TDE					40				49			32
	DDT					20				—			—
	Dieldrin					T				12			24
	[3] PCB's					2,800				—			960

TABLE N-2.—*Distribution of organochlorine residues in* C. virginica *for each sampling station by date of collection—Virginia*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 9.—HOSPITAL POINT—58 SAMPLES [1]—Continued													
1972	DDE		34										
	TDE		32										
	DDT		—										
	Dieldrin		Lost										
	[3] PCB's		1,440										
STATION 10.—LYNNHAVEN BAY—62 SAMPLES [1]													
1965	DDE							26	18	13	14	13	31
	TDE							49	33	10	24	14	40
	DDT							17	12	T	—	T	T
	Dieldrin							10	—	—	—	—	—
1966	DDE	19	20	17	32	16	25	36	16	16	14	17	14
	TDE	25	29	20	39	20	41	59	21	24	22	27	26
	DDT	—	—	—	T	—	11	15	—	—	T	—	T
1967	DDE	16	22	19	29	15	24	34	17	21	20	20	18
	TDE	19	27	21	36	18	35	57	33	33	32	27	25
	DDT	T	T	—	T	T	20	22	17	16	17	11	10
	Dieldrin	—	—	—	16	—	—	—	—	—	—	—	—
1968	DDE	19	T	29	18	27	30	15	14	11	16	15	19
	TDE	22	—	43	18	28	45	T	21	13	20	12	20
	DDT	T	—	12	—	10	27	12	T	—	T	—	T
	Dieldrin	—	—	13	—	—	—	—	—	—	—	—	—
1969	DDE	18	16	12	11	16	12		27	14	11	20	18
	TDE	16	22	21	11	21	16		28	18	20	28	23
	DDT	—	T	T	—	T	—		17	T	10	—	—
	Dieldrin	—	—	—	—	—	—		—	—	—	10	—
1970	DDE	—	20	—	T	11	28			18		18	14
	TDE	—	26	—	—	—	29			20		12	23
	DDT	T	—	—	—	—	T			10		T	T

[1] Each sample represents 15 or more mature mollusks.
[2] Calculated as Aroclor 1242®.
[3] Calculated as Aroclor 1254®.

SECTION O.—WASHINGTON

The Pacific oyster, *Crassostrea gigas*, was used to monitor 19 estuarine sites at monthly intervals in the period October 1965 - December 1968. All samples were analyzed at the Gulf Breeze Laboratory. The approximate station locations are shown in Fig. O-1. A summary of data on organochlorine residues in the monitored species, *C. gigas*, is presented in Table O-1, and the distribution of residues in this species for each sampling station by date of collection in Table O-2.

The monitoring program was terminated in Washington after 3 years because of the absence of detectable DDT residues in most samples. This was due to the absence of DDT pollution and not because of any lack of sensitivity on the part of the monitored species. Analyses of samples of the Pacific oyster in California waters had demonstrated its ability to store organochlorine residues at levels comparable to other molluscan species in the same estuary.

The overall incidence of DDT residues in Washington samples was only 11%. The maximum residue detected, 176 ppb, was the obvious result of a single pollution incident. Station 18 was the only one demonstrating a continuing, but low-level pollution problem. The fact that residues at this station were primarily DDT rather than one of its metabolites suggests a direct application of the pesticide to coastal waters. Analytical data are too few, even at Station 18, to indicate any trend in DDT pollution. The overall picture is that of an estuarine area of the United States that was remarkably free from DDT pollution in the period 1965-68.

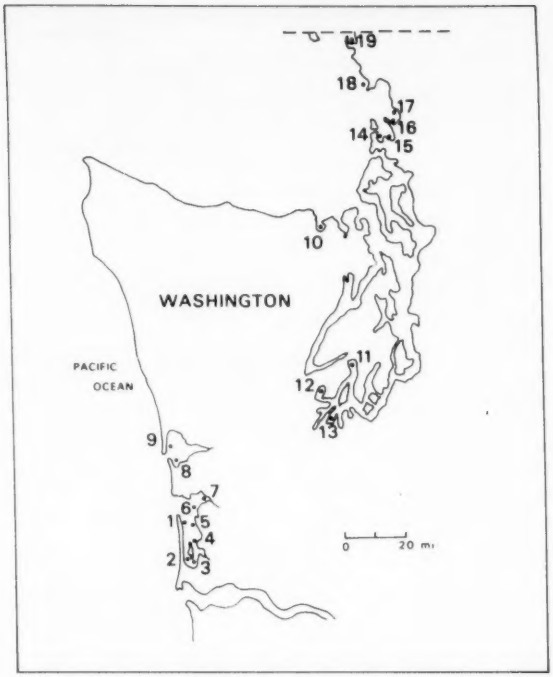

FIGURE O-1.—*Diagram of coastal Washington showing approximate location of monitoring stations*

1. Stackpole Harbor—Willapa Bay
2. Olson Slough—Willapa Bay
3. Bear River—Willapa Bay
4. Naselle River—Willapa Bay
5. Nemah River—Willapa Bay
6. Stony Point—Willapa Bay
7. South Bend—Willapa Bay
8. Beardslee Slough—Grays Harbor
9. Oyehut—Grays Harbor
10. Sequim Bay
11. North Bay Reserve—Puget Sound
12. Oakland Bay Reserve—Puget Sound
13. Mud Bay—Puget Sound
14. Padilla Bay—Padilla Bay
15. Swinomish—Padilla Bay
16. Scott Point—Samish Bay
17. Rock Point—Samish Bay
18. Lummi—Lummi Bay
19. Blaine—Drayton Harbor

TABLE O-1.—*Summary of data on organochlorine residues in the monitored species* (C. gigas), *1965-68—Washington*

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (µg/kg)	
				DDT	Dieldrin
1	Stackpole Harbor	1965-68	38	9 (25)	
2	Olson Slough	1966-68	30	7 (55)	
3	Bear River	1965-68	38	3 (17)	
4	Naselle River	1965-68	38	1 (11)	1 (120)
5	Nemah River	1965-68	39	4 (21)	
6	Stony Point	1965-68	39	10 (176)	
7	South Bend	1965-68	39	6 (23)	
8	Beardslee Slough	1965-68	37	2 (27)	
9	Oyehut	1966-68	36		
10	Sequim Bay	1966-68	31		
11	North Bay Reserve	1965-68	33		
12	Oakland Bay Reserve	1965-68	33		

TABLE O-1.—*Summary of data on organochlorine residues in the monitored species* (C. gigas), *1965-68—Washington*—Continued

Station Number	Location	Monitoring Period	Number of Samples [1]	Number of Positive Samples and Maximum Residue ( ) Detected in PPB (μg/kg)	
				DDT	Dieldrin
13	Mud Bay	1965-68	32		
14	Padilla Bay	1965-68	39	8 (17)	
15	Swinomish	1965-68	38	1 (T)	
16	Scott Point	1965-68	39	4 (10)	
17	Rock Point	1965-68	37		
18	Lummi	1965-68	38	23 (99)	
19	Blaine	1965-68	38		
	Occasional stations (2)	1966	3		
Total number of samples			695		
Percent of samples positive for indicated compound				11	<1

NOTE: T = >5 but <10 ppb.
[1] Each sample represents 15 or more mature mollusks.

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*
[Blank = no sample collected; — = no residue detected above 5 ppb; T = >5 but <10 ppb]

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 1.—STACKPOLE HARBOR—38 SAMPLES [1]													
1965	DDE										T	T	—
	TDE										T	—	—
	DDT										T	—	—
1966	DDE	—	—	T	T	T	13	11	—	T	—	—	—
	TDE	—	—	T	—	—	12	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	T	—	—	—		—	—	—
	TDE	—	—	—	—	T	—	—	—		—	—	—
	DDT	—	—	—	—	—	—	—	—		—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 2.—OLSON SLOUGH—30 SAMPLES [1]													
1966	DDE						—	20	T	—	—	—	—
	TDE						—	19	10	—	—	—	—
	DDT						—	16	—	—	—	—	—
1967	DDE	—	T	—	T	—	T	—	—		—	—	—
	TDE	—	11	—	T	—	12	—	—		—	—	—
	DDT	—	14	—	14	—	14	—	—		—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 2.—OLSON SLOUGH—30 SAMPLES [1]—Continued													
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	T	—	—	—	—	—	—	—	—	—	—	—
	DDT	15	—	14	—	—	—	—	—	—	—	—	—
STATION 3.—BEAR RIVER—38 SAMPLES [1]													
1965	DDE										—	—	T
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	T	—	—	—	—	—	—
	TDE	—	—	—	—	—	12	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	T	—	—		—	—	—
	TDE	—	—	—	—	—	T	—	—		—	—	—
	DDT	—	—	—	—	—	T	—	—		—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 4.—NASELLE RIVER—38 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—		—	—	—
	TDE	—	—	—	—	—	—	—	—		—	—	—
	DDT	—	—	—	—	—	—	—	—		—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	11	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	—	—	—	—	—	—	120	—	—	—	—	—
STATION 5.—NEMAH RIVER—39 SAMPLES [1]													
1965	DDE										—	T	—
	TDE										—	—	—
	DDT										—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 5.—NEMAH RIVER—39 SAMPLES [1]—Continued													
1966	DDE	—	—	—	—	—	11	T	—	—	—	—	—
	TDE	—	—	—	—	—	10	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
STATION 6.—STONY POINT—39 SAMPLES [1]													
1965	DDE										T	T	—
	TDE										14	T	—
	DDT										T	—	—
1966	DDE	T	—	—	T	T	T	13	—	—	—	—	—
	TDE	T	—	—	T	—	11	11	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	26	—	—	—	—
	DDT	—	—	—	—	—	—	—	150	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	T	—	T	—	—	—	—	—	—	—	—	—
STATION 7.—SOUTH BEND—39 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	T	—	T	T	T	—	10	—	—	—	—	—
	TDE	T	—	16	T	—	—	13	—	—	—	—	—
	DDT	—	—	—	T	—	—	—	—	—	—	—	—
1967	DDE	—	T	—	—	—	—	—	—	—	—	—	—
	TDE	—	T	—	—	—	—	—	—	—	—	—	—
	DDT	—	T	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 8.—BEARDSLEE SLOUGH—37 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	T	—	T	—	—	—	—	—
	TDE	—	—	—	—	11	—	11	—	—	—	—	—
	DDT	—	—	—	—	11	—	10	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 9.—OYEHUT—36 SAMPLES [1]													
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 10.—SEQUIM BAY—31 SAMPLES [1]													
1966	DDE			—			—	—	—	—	—	—	—
	TDE			—			—	—	—	—	—	—	—
	DDT			—			—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	
	TDE	—	—	—	—	—	—	—	—	—	—	—	
	DDT	—	—	—	—	—	—	—	—	—	—	—	
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 11.—NORTH BAY RESERVE—33 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—		—	—	—	—	—	—	—	—
	TDE	—	—	—		—	—	—	—	—	—	—	—
	DDT	—	—	—		—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—			
	TDE	—	—	—	—	—	—	—	—	—			
	DDT	—	—	—	—	—	—	—	—	—			
STATION 12.—OAKLAND BAY RESERVE—33 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—		—	—	—	—	—	—	—	—
	TDE	—	—	—		—	—	—	—	—	—	—	—
	DDT	—	—	—		—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—			
	TDE	—	—	—	—	—	—	—	—	—			
	DDT	—	—	—	—	—	—	—	—	—			
STATION 13.—MUD BAY—32 SAMPLES [1]													
1965	DDE												—
	TDE												—
	DDT												—
1966	DDE	—	—	—		—	—	—	—	—	—	—	—
	TDE	—	—	—		—	—	—	—	—	—	—	—
	DDT	—	—	—		—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 13.—MUD BAY—32 SAMPLES [1]—Continued													
1968	DDE		—	—	—	—	—	—	—	—			
	TDE		—	—	—	—	—	—	—	—			
	DDT		—	—	—	—	—	—	—	—			
STATION 14.—PADILLA BAY—39 SAMPLES [1]													
1965	DDE										T	T	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	T	—	—	—	T	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	T	T	T	—
	TDE	—	—	—	—	—	—	—	—	—	—	T	—
	DDT	—	—	—	—	—	—	—	—	12	T	T	—
1968	DDE	T	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	T	—	—	—	—	—	—	—	—	—	—	—
STATION 15.—SWINOMISH—38 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—		—	—
	TDE	—	—	—	—	—	—	—	—	—		—	—
	DDT	—	—	—	—	—	—	—	—	—		—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	T	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
STATION 16.—SCOTT POINT—39 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 16.—SCOTT POINT—39 SAMPLES [1]—Continued													
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	T	T	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	T	T	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	T	—	—	—	—
STATION 17.—ROCK POINT—37 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—		—	
	TDE	—	—	—	—	—	—	—	—	—		—	
	DDT	—	—	—	—	—	—	—	—	—		—	
STATION 18.—LUMMI—38 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	T	T
	TDE	—	—	—	—	—	—	—	—	—	—	15	—
	DDT	—	—	—	—	—	T	—	—	—	—	—	18
1967	DDE	T	—	T	T	T	11	T	T	—	T	—	T
	TDE	10	—	T	11	T	14	T	T	T	T	—	T
	DDT	25	19	29	44	42	74	34	14	15	21	21	19
1968	DDE	T	—	—	—	10	T	T	T	—	—	—	
	TDE	—	—	—	—	T	T	—	—	—	—	—	
	DDT	17	19	22	33	25	24	14	17	—	—	—	

TABLE O-2.—*Distribution of organochlorine residues in* C. gigas *for each sampling station by date of collection—Washington*—Continued

Year	Compound	Residues in PPB (μg/kg)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
STATION 19.—BLAINE—38 SAMPLES [1]													
1965	DDE										—	—	—
	TDE										—	—	—
	DDT										—	—	—
1966	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1967	DDE	—	—	—	—	—	—	—	—	—	—	—	—
	TDE	—	—	—	—	—	—	—	—	—	—	—	—
	DDT	—	—	—	—	—	—	—	—	—	—	—	—
1968	DDE	—	—	—	—	—	—	—	—	—	—	—	
	TDE	—	—	—	—	—	—	—	—	—	—	—	
	DDT	—	—	—	—	—	—	—	—	—	—	—	

[1] Each sample represents 15 or more mature mollusks.

PESTICIDES IN WATER

Organochlorine Insecticide Residues in Streams Draining Agricultural, Urban-Agricultural, and Resort Areas of Ontario, Canada—1971[1]

J. R. W. Miles and C. R. Harris

ABSTRACT

Organochlorine insecticide residues in water systems draining agricultural, urban-agricultural, and resort areas of Ontario, Canada, were compared by analysis of water, bottom mud, and fish, collected during the period from mid-April to mid-October 1971. Insecticides detected were p,p'-DDT, o,p'-DDT, p,p'-TDE, o,p'-TDE, p,p'-DDE, γ-chlordane, dieldrin, endrin, endosulfan, heptachlor, heptachlor epoxide, lindane, and aldrin. Insecticide concentrations in water from all three areas were less than the "Maximum Reasonable Stream Allowances" for growing fish that are safe for human consumption.

The concentrations of total DDT in the water were combined with water flow data to calculate the weekly rate of transport of total DDT at each sampling time. The greatest transport of total DDT was by the Muskoka River which drains the Muskoka Lakes resort area where DDT was used until 1966 for control of biting flies; a peak of 11.8 lb total DDT per week was recorded in May, but this transport quickly lessened, resulting in a May to October average of 1.9 lb total DDT per week. Corresponding figures for the Thames River (urban-agricultural) were peak 2.5 lb and average 0.4 lb total DDT per week and for Big Creek (agricultural), peak 0.5 lb and average 0.2 lb per week.

The ratio of concentration of total DDT in mud to total DDT in water was as great as 800; total DDT in fish to total DDT in water was as great as 1 million. The ratio of p,p'-TDE to p,p'-DDT was <1 in water but >1 in bottom mud, indicating possible dechlorination of p,p'-DDT to p,p'-TDE in the bottom mud. Polychlorinated biphenyls (PCB's) were present in the urban-agricultural area samples of bottom mud and fish at levels up to 217 ppm and about 0.4 ppm, respectively.

Introduction

In a previous issue of this Journal (*4*), this laboratory reported on the transport of insecticides into Lake Erie by two water systems draining agricultural areas in southwestern Ontario (Big Creek, which flows into Lake Erie, and a controlled drainage system near Erieau, Ontario, the water of which is pumped into Lake Erie). In 1971, in order to compare residue contributions from differing areas of insecticide usage, the present study was made of insecticides transported by water systems draining agricultural, urban-agricultural, and resort areas. The agricultural area studied (Fig. 1, Area 1) was the same 280 square miles of predominantly tobacco farms in Norfolk County, Ontario, reported in the earlier study, whose drainage enters Lake Erie by Big Creek. DDT has been used extensively in this area for many years primarily for cutworm and hornworm control. Since January 1970, use of DDT has been restricted to cutworm control on tobacco and requires a provincial government permit prior to its use. The urban-agricultural area (Fig. 1, Area 2) was the City of London, Ontario, (population 200,000) on the Thames River which drains 1,200 square miles of mixed agricultural land (chiefly dairy cattle) before flowing through London; the Thames River flows into Lake St. Clair which empties into Lake Erie via the Detroit River. DDT usage in this area has also been subject to the provincial ban of 1970. The resort area (Fig. 1, Area 3) was the Muskoka Lakes region of Ontario, 1,700 square miles which drains into Georgian Bay and Lake Huron by the Muskoka River. DDT had been used extensively in this area for biting fly control until 1966 when this use was discontinued. Average water flow for the three streams during 1971 was Big Creek (agricultural) 190 cubic feet per second (CFS), Thames River (urban-agricultural) 1,030 CFS, and Muskoka River (resort) 2,421 CFS.

[1] Contribution No. 528 from the Research Institute, Canada Department of Agriculture, University Sub Post Office, London 72, Ontario.

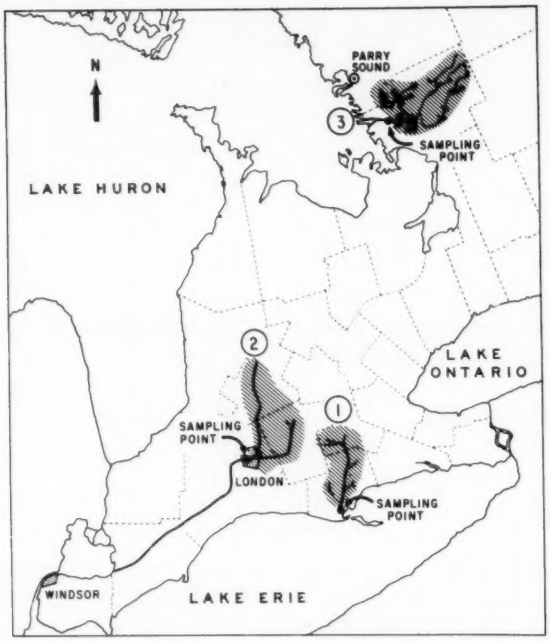

FIGURE 1.—*Partial map of Ontario, Canada, showing drainage areas of 1—Big Creek (agricultural), 2—Thames River (urban-agricultural), and 3—Muskoka Lakes (resort)*

In Big Creek drainage area, the overburden consists mainly of glacial till of Pleistocene age with dominantly coarse-textured soil formed on sand and gravel. The adjacent Thames River drainage area is also of glacial till but is dominantly fine-textured soil formed on very fine sands and silts. The Muskoka Lakes region is a Precambrian area with little or no true soil and consists of lakes and rock outcrops with conifers growing on shallow soils and detritus trapped between rocks.

Materials and Methods

SAMPLE COLLECTION

Water, bottom mud, and fish samples were collected between mid-April and mid-October 1971. Water and botton mud samples in Big Creek and the Thames River were taken every 2 weeks. Depth-integrated water samples were collected in 32-fluid ounce, narrow-necked glass bottles clamped to a 24-ft long aluminum pole. The contents of two bottles were combined for one water sample. Bottom mud samples were collected using a sampler (authors' design) consisting of a steel container, 3¼ inches in diameter and 1¾ inches deep, attached to the end of a 24-ft aluminum pole. Five samples of mud were taken, ranging from near the bank to mid-stream, and combined into one composite sample. Water and bottom mud samples from the Muskoka River were taken at monthly intervals by personnel of the Ontario Water Resources Commission and shipped to London, Ontario, for analysis. The difference in frequency from the other two rivers was necessitated by the greater distance of the Muskoka Lakes from the laboratory. Water samples were collected from 10 feet below the surface using Kemmerer bottles. Bottom mud samples were collected with an Eckmann Dredge. Water depth at sampling points was about 30 feet.

Stream flow data were measured and compiled by personnel of the Water Survey of Canada using the "General Procedure for Gaging Streams" (*6*).

Fish were collected in the fall of 1971 by personnel of the Ontario Department of Lands and Forests, using electric shockers and gill nets.

EXTRACTION AND FRACTIONATION

Water plus any suspended matter was analyzed "as is" without filtration. The contents of the bottles were measured by weighing bottles before and after emptying the contents into a 2-liter separatory funnel. The empty bottles were rinsed with 10 ml acetone to remove any insecticide adsorbed on the walls, and the acetone rinse was added to the separatory funnel. The bottles were then rinsed with 100 ml of hexane which was also added to the separatory funnel. The funnel was shaken for 2 minutes, and the layers allowed to separate. The aqueous layer was withdrawn into a second 2-liter separatory funnel and extracted twice more with 50-ml portions of hexane, the first separatory funnel being used twice. The three hexane extracts were combined in a 500-ml round-bottom flask and concentrated for fractionation on a Florisil column.

Extraction of bottom mud and fish and fractionation of extracts on Florisil have been previously described (*4*).

GAS-LIQUID CHROMATOGRAPHY

Two Model 1400 and one Model 1200 Varian Aerograph gas chromatographs were used. The column of one Model 1400 was packed with 5% XE-60, the other with mixed 3% DC-200/4.5% QF-1. The column of the Model 1200 was packed with 5% DC-200. Solid support in all columns was 80/100 mesh Chromosorb W, A.W. DMCS treated; all columns, 6 ft long x 2 mm (i.d.), were operated at 180° C. Nitrogen was the carrier gas at a flow rate of 40 ml/min.. Tritium electron capture detectors were used on all three gas chromatographs. All samples were run on all three columns.

In the samples of bottom mud and fish from the urban-agricultural area (Thames River), interference from polychlorinated biphenyls (PCB's) measured as Aroclor 1254® (up to 217 ppm in bottom mud, about 0.4 ppm in fish) was too great to allow direct GLC determination of *p,p'*-DDT, *o,p'*-DDT, and *p,p'*-DDE. In these samples the DDT compounds were converted to dichlorobenzophenones, separted from the PCB's on the Florisil column, and then assessed by GLC (*5*).

RECOVERY

Recoveries of reported insecticides from water fortified at 100 parts per 10^{12} (American trillion) ranged from 75% to 102%. Recoveries of the insecticides added to bottom mud at 0.2 ppm were 91% to 103%. Recoveries of the reported insecticides added directly to fish muscle at 0.1 ppm before extraction ranged from 91% to 95%.

Results and Discussion

The concentrations of insecticides found in water samples are given in Table 1. In all three water systems, residues of *p,p'*-DDT were the highest, followed by dieldrin and *o,p'*-DDT. Peak concentrations for all insecticides occurred during spring runoff in May, with subsequent leveling off at lower concentrations during the rest of the sampling period. For these uniform periods, data have been condensed by reporting average concentrations and ranges (Table 1). For the sampling period, the averages for total DDT in water were similar for the three areas—28, 23, and 18 parts per 10^{12} (American trillion) for agricultural, urban-agricultural, and resort areas, respectively. All insecticide concentrations in water were below the "Maximum Reasonable Stream Allowances" (2) in which it is presumably safe to grow fish for human consumption.

The concentrations of total DDT in the water were combined with water flow data measured in cubic feet per second (CFS) to calculate the weekly rate of transport of total DDT at each sampling time (Fig. 2). Although the peak transport (in May) for the Muskoka River (resort area) was 11.8 lb total DDT per week, the average for the period sampled was 1.9 lb per week.

TABLE 1.—*Insecticide concentrations in water of three streams in Ontario, Canada—1971*

Date (1971)	Residues in Parts per 10^{12} (American trillion)											
	Total DDT	*p,p'*-DDE	*o,p'*-DDT	*p,p'*-DDT	*p,p'*-TDE	Dieldrin	γ-Chlordane	Endosulfan	Endrin	Heptachlor	Aldrin	Lindane
BIG CREEK (AGRICULTURAL)												
Apr. 13	30	5	13	10	2	3	<1	2	<1	<1	—	—
26	31	5	13	10	3	41	<1	2	<1	<1	—	—
May 4	75	15	13	40	11	23	<1	11	<1	2	—	—
11	79	5	12	58	4	11	<1	<1	<1	<1	—	—
25	37	4	4	27	2	6	<1	<1	1	<1	—	—
June 8	37	4	5	24	4	5	<1	<1	3	<1	—	—
22	19	1	2	13	3	4	<1	<1	7	<1	—	—
July 26 to Oct. 12 [1]												
Average	16	2	2	9	2	4	<1	1	1	<1	—	—
Range	11-20	1-3	1-3	5-12	1-3	3-6	<1-2	<1-3	<1-3	<1-1	—	—
THAMES RIVER (URBAN-AGRICULTURAL)												
Apr. 15	22	3	10	7	2	4	<1	1	—	<1	<1	1
26	18	3	3	9	3	32	<1	2	—	<1	<1	1
May 5	73	3	13	53	4	7	<1	3	—	1	<1	1
12	50	3	4	40	3	7	<1	<1	—	<1	<1	<1
26	24	2	3	16	3	7	<1	<1	—	2	2	<1
June 9 to Sept. 15 [1]												
Average	13	1	2	8	2	4	2	<1	—	<1	<1	1
Range	<10-16	<1-2	1-4	5-9	<1-5	3-5	<1-6	<1	—	<1-1	<1-2	<1-4
Sept. 29	30	2	4	23	1	9	8	<1	—	1	7	<1
Oct. 13	24	1	3	18	2	18	21	<1	—	<1	1	<1
28	19	3	2	11	3	8	3	<1	—	<1	<1	1
MUSKOKA RIVER (RESORT)												
May 5	57	9	6	28	14	11	—	—	2	<1	<1	<1
26	20	3	4	12	1	2	—	—	<1	<1	<1	<1
June 10	17	1	5	11	<1	4	—	—	<1	<1	<1	<1
June 23 to Nov. 4 [1]												
Average	10	1	2	7	1	4	—	—	<1	<1	<1	<1
Range	8-13	<1-2	1-2	4-9	<1-2	3-5	—	—	<1-1	<1	<1	<1

NOTE: — = not detected; <1 indicates that qualitative identification of the compound was made on all three GLC liquid phases, but the amount was less than the lowest level of reporting, i.e., <1 parts per 10^{12} (American trillion). Heptachlor epoxide and *o,p'*-TDE were not detected in water samples.

[1] Because of the leveling off of insecticide residues at lower concentrations for these uniform periods, data have been condensed by reporting average concentrations and ranges.

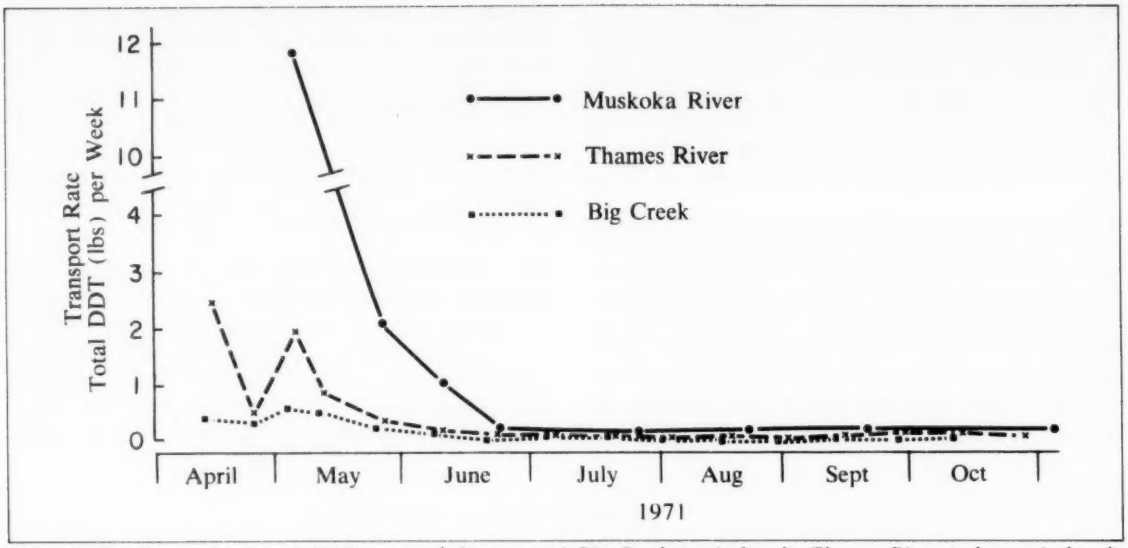

FIGURE 2.—*Transport of total DDT per week by water of Big Creek (agricultural), Thames River (urban-agricultural), and Muskota River (resort)*

Similarly, the Thames River (urban-agricultural) averaged 0.4 lb total DDT per week and Big Creek (agricultural) averaged 0.2 lb total DDT per week. To properly relate these data, the size of the three drainage areas must be considered, i.e. resort, 1,700 square miles; urban-agricultural, 1,200 square miles; and agricultural, 280 square miles. Average amounts of total DDT transported per week per 100 square miles were: Muskoka River (resort)-0.11 lb; Big Creek (agricultural)-0.05 lb; and Thames River (urban-agricultural)-0.03 lb. It is surprising that based on area the resort district is still the largest contributor of DDT, since the last official use of DDT for biting-fly control was in 1966. In part, this difference may be explained by the different techniques used in these areas for insect control. In the agricultural area (Big Creek), DDT, applied primarily for cutworm control on tobacco, was incorporated into the soil. By contrast, in the resort area (Muskoka River), DDT was applied by ground or air application over land and water. As noted in the introduction, the Muskoka district has little or no true soil, thus the insecticide would tend to accumulate in the surface detritus with the possibility of greater surface erosion.

The concentrations of insecticides found in the bottom mud are listed in Table 2. These concentrations were uniform for each compound, and results for each month have been averaged for presentation in this table. Concentrations of total DDT in the bottom mud of Big Creek (agricultural) were 604 times those in the water, while the ratios of total DDT in bottom mud/water for the Thames River (urban-agricultural) and the Muskoka River (resort) were 109:1 and 863:1, respectively. The reason for the low bottom mud/water ratio for total DDT in the Thames River is that the Thames had the lowest insecticide concentration in the bottom mud, average total DDT = 2.5 parts per 10^9 (American billion). These data may be interpreted to mean that the DDT contamination in the Thames River did not result from erosion of treated soil into the stream, but rather from domestic DDT usage with direct contamination of the water.

Ratios of *p,p'*-DDE:*p,p'*-TDE:*p,p'*-DDT in bottom mud may indicate the metabolic history of residues in specific areas. These ratios were as follows: Big Creek (agricultural) 0.7:1.0:1.0; Thames River (urban-agricultural) 1.9:5.7:1.0; and Muskoka River (resort) 2.5:1.8:1.0. The higher DDE/DDT ratios in the Thames and Muskoka Rivers compared to Big Creek could indicate that these residues are older (the last official use of DDT in the resort area was in 1966). The high TDE/DDT ratio in the Thames River bottom mud suggests greater anaerobic dechlorination of DDT (*1,3*) and may indicate the presence of sewage.

Residues found in fish from the three areas are listed in Table 3. Magnification of total DDT concentration from water to fish was greatest (1 million times) in the lake trout from the resort area. No direct comparisons can be made because the same species of fish were not obtained from all three areas, but it is interesting to note the differences in the ratios of *p,p'*-DDE:*p,p'*-TDE:*p,p'*-DDT in fish from Big Creek (agricultural)-3.6:0.7:1.0 and from Muskoka River (resort)-0.6:1.0:1.0, indicating more metabolism to DDE in the smaller fish from the agricultural area than in the larger fish from

the resort area. In the fish from the urban-agricultural area (Thames River), levels of total DDT were very low (0.02-0.04 ppm), and the major part of this residue was *p,p'*-DDE and *p,p'*-TDE; levels of *p,p'*-DDT were <0.01 ppm.

Summary

Insecticide residues in water, bottom mud, and fish were compared in streams draining agricultural, urban-agricultural, and resort areas during spring runoff and summer of 1971. Transport of total DDT was calculated by combining insecticide concentrations in water with stream flow measurements. Average transports (April-October) of total DDT were Muskoka River (resort) 0.11 lb per week per 100 square miles, Big Creek (agricultural) 0.05 lb per week per 100 square miles, and Thames River (urban-agricultural) 0.03 lb per week 100 square miles. The heaviest contributor of DDT among these three water systems was the resort area in spite of the fact that official DDT usage in that area ceased in 1966. Fish from the resort area contained up to 19 ppm total DDT compared to a high of 1.3 ppm from the agricultural area stream. Bottom mud and fish from the urban-agricultural river contained PCB's (up to 217 ppm in the mud and about 0.04 ppm in the fish). The very small concentration of DDT in the bottom mud of the urban river indicated that the DDT in this water system did not come from erosion of treated soil.

Acknowledgments

The authors wish to make the following acknowledgments:

(1) GLC analyses, Mrs. Patricia Moy;

(2) collection of Muskoka samples, personnel of the Ontario Water Resources Commission;

(3) collection of fish samples, the Ontario Department of Lands and Forests; and

(4) stream flow data, the Water Survey of Canada, Division of Environment, Canada.

See Appendix for chemical names of compounds discussed in this paper.

TABLE 2.—*Insecticide concentrations in bottom mud from three streams in Ontario, Canada—1971*

Date (1971)	Residues in parts per 10^9 (American billion), Dry-Weight Basis[1]								
	Total DDT	*p,p'*-DDE	*o,p'*-DDT	*p,p'*-DDT	*o,p'*-TDE	*p,p'*-TDE	Dieldrin	γ-Chlordane	Endrin
BIG CREEK (AGRICULTURAL)									
Apr.	21.0	4.0	1.5	10.2	0.4	4.9	0.8	0.2	<0.2
May	15.6	3.2	0.7	6.3	0.7	4.7	0.7	0.1	0.2
June	19.2	4.8	0.7	6.1	1.1	6.5	0.8	<0.1	<0.2
July	17.9	4.8	0.6	5.2	1.0	6.4	0.7	<0.1	<0.2
Aug.	15.9	4.2	0.3	3.9	1.1	6.4	0.7	<0.1	<0.2
Sept.	14.2	4.1	<0.3	3.9	0.9	5.3	0.7	<0.1	0.2
Oct.	22.2	5.0	0.9	7.8	1.0	7.5	4.5	3.1	0.3
THAMES RIVER (URBAN-AGRICULTURAL)									
May	4.3	1.1	—	—	—	3.2	0.4	—	—
June	2.4	0.5	—	0.2	—	1.6	0.5	—	—
July	2.1	0.5	—	0.4	—	1.3	0.4	—	—
Aug.	2.5	0.5	—	<0.1	—	2.0	0.6	—	—
Sept.	2.3	0.4	—	0.3	—	1.7	0.6	—	—
Oct.	2.0	0.4	—	0.7	—	0.9	0.3	—	—
MUSKOKA RIVER (RESORT)									
May	19.1	7.5	<0.4	4.1	1.1	6.5	1.4	1.9	0.3
June	21.7	9.3	<0.4	3.9	1.1	7.4	0.9	<0.1	<0.3
July	12.0	7.0	<0.4	1.6	0.4	3.0	0.6	<0.1	<0.3
Aug.	8.7	3.9	<0.4	1.3	0.4	3.1	0.6	<0.1	<0.3
Sept.	12.7	7.0	<0.4	0.8	0.6	4.3	1.0	0.5	<0.3

NOTE: — = not detected; <0.1 indicates qualitative identification of the compound on all three GLC liquid phases, but the amount was less than the lowest level of reporting. Aldrin, endosulfan, heptachlor, heptachlor epoxide, and lindane were not detected in bottom mud samples.

[1] Because concentrations were very uniform, results for each month have been averaged for presentation in this table.

TABLE 3.—*Insecticide concentrations in fish muscle from three streams in Ontario, Canada—1971*

Species	Number of Fish in Samples	Residues in PPM										Percent Fat
		Total DDT	*p,p'*-DDE	*o,p'*-DDT	*p,p'*-DDT	*o,p'*-TDE	*p,p'*-TDE	Dieldrin	γ-Chlordane	Endrin	Heptachlor Epoxide	
BIG CREEK (AGRICULTURAL)												
Brown trout	6	1.27	0.79	0.04	0.31	0.01	0.13	0.03	—	<0.01	<0.01	1.8
Rainbow trout												
Small (12-15 cm)	7	0.42	0.37	0.01	—	<0.01	0.04	0.01	—	0.01	<0.01	1.1
Medium (17-22 cm)	8	0.23	0.17	0.01	0.03	<0.01	0.03	0.01	—	0.01	<0.01	0.9
Rock bass	8	0.49	0.30	0.02	0.10	<0.01	0.06	0.03	—	0.03	<0.01	4.0
Bluegill	8	0.45	0.27	0.01	0.10	<0.01	0.07	0.03	—	0.03	<0.01	4.0
THAMES RIVER (URBAN-AGRICULTURAL)												
Carp	3	0.03	0.02	—	<0.01	—	0.01	<0.01	<0.01	<0.01	—	0.8
Bass												
Small (9-14 cm)	3	0.02	0.01	—	<0.01	—	0.01	<0.01	<0.01	<0.01	—	1.8
Medium (16-17 cm)	5	0.04	0.02	—	<0.01	—	0.01	<0.01	<0.01	<0.01	—	1.6
MUSKOKA LAKES (RESORT)												
White sucker	1	1.98	0.96	0.04	0.76	0.01	0.21	0.01	<0.01	<0.01	<0.01	2.8
Lake trout	1	2.47	1.25	0.10	0.90	0.01	0.21	0.01	<0.01	<0.01	<0.01	1.6
Lake trout	1	16.57	5.58	0.71	8.92	0.07	1.29	0.04	0.02	0.01	0.02	9.5
Lake trout	1	5.71	2.32	0.15	2.76	0.02	0.46	0.01	0.01	<0.01	0.01	2.6
Cisco	1	5.11	0.95	0.21	3.41	0.01	0.54	0.02	0.02	<0.01	0.01	8.2
Cisco	1	19.75	3.04	1.00	14.82	0.01	0.88	0.03	0.03	0.01	0.01	9.8
Cisco	1	1.41	0.41	0.05	0.84	<0.01	0.11	0.01	0.01	<0.01	<0.01	4.6
Cisco	1	4.05	0.98	0.10	2.78	<0.01	0.19	0.01	0.01	<0.01	<0.01	5.0
Cisco	1	2.87	0.75	0.06	1.87	0.01	0.18	0.01	0.01	<0.01	<0.01	4.2

NOTE: — = not detected; <0.01 indicates qualitative confirmation on all three GLC columns, but less than the reporting level of 0.01 ppm. Aldrin, endosulfan, heptachlor, and lindane were not detected in fish muscle samples.

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PESTICIDES IN SOIL

Organochlorine Pesticide Residues in Soils and Crops of the Corn Belt Region, United States—1970

A. E. Carey[1], G. B. Wiersma[1], H. Tai[2], and W. G. Mitchell[2]

ABSTRACT

In order to determine the levels of organochlorine pesticides in the Corn Belt region of the United States, a study was initiated in 1970 to sample 400 sites in 12 States. The sampling areas followed the historical boundaries of the Corn Belt and were selected from sites designated for the National Soils Monitoring Program. At each site a 2-qt soil sample (composite of 50, 2- by 3-inch cores, taken in a grid pattern over each 10-acre site) was collected as well as a composite sample of any available standing crop. In addition, use records were obtained at each site for the kinds and amounts of pesticides used during the 1970 cropping season as well as the names of other pesticides known to have been used in the previous 5 years. These data indicated that pesticides had been applied to most of the agricultural acreages in the study area (up to 85%). Forty compounds were identified in use records: 20 herbicides, 17 insecticides, and 3 fungicides. Atrazine was most widely used, followed by captan, malathion, 2,4-D, propachlor (Ramrod®), amiben, and aldrin. Forty-five percent of the soil samples analyzed contained residues; 11 pesticides or metabolites were detected. Arsenic, which can occur naturally in soil, was detected in nearly all soil samples. The most commonly detected residues were those of aldrin, chlordane, and dieldrin. Seven compounds, including four DDT metabolites, were detected in cornstalks, soybeans, sorghum grain, sorghum fodder, and hay.

Introduction

Historically, the Corn Belt of the United States has been defined as that area stretching from central Ohio to Nebraska and Kansas where agricultural acreage has been devoted almost exclusively to the growing of corn and silage. Although corn is still the main crop, modern agricultural trends have diversified the production in this particular region to include a variety of other food and feed grains. In 1969 the 12 states outlined in Fig. 1 produced 79% of the total national corn crop, and at the same time, produced 73% of the total soybean crop and 44% of the total sorghum grain (*1*).

Between 1954 and 1959 there was a 22% decrease in the acreage planted to corn; however, the decrease was offset by a 115% increase in yield per harvested acre during the same time period, amounting to a 75% increase in total production. These increases were partly due to more extensive use of fertilizers and pesticides.

The production and sales of synthetic organic pesticides have followed a generally upward trend which began in the 1940's when many of the chemicals were first introduced; however, in 1969, both production and sales declined for the first time since 1957 (*2*).

The main objective of this study was to determine the levels in 1970 of organochlorine pesticide residues in soils and crops of the Corn Belt region as shown in Fig. 1. In addition, pesticide use records were obtained for sampling sites, indicating the kinds and amounts of pesticides used for the 1970 cropping season as well as the names of any other pesticides known to have been used on the sites in the previous 5 years.

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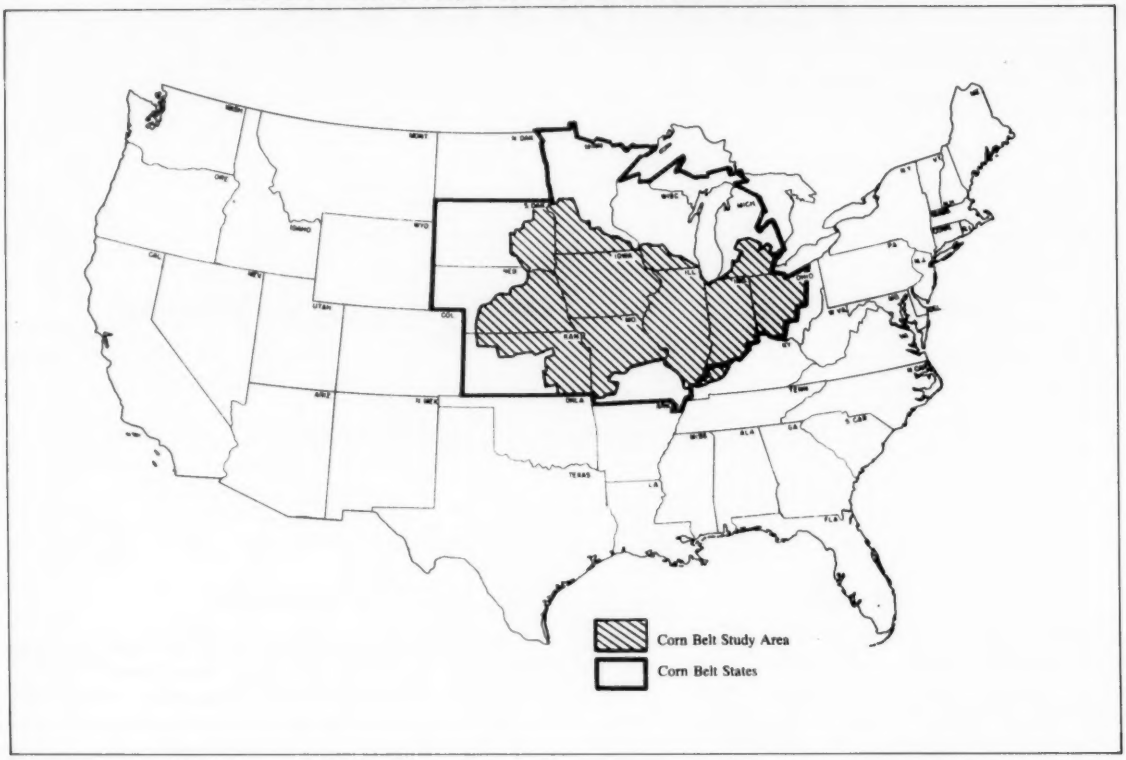
[2] Technical Services Division, Office of Pesticide Programs, Environmental Protection Agency, Mississippi Test Facility, Bay St. Louis, Miss. 39520.

FIGURE 1.—*Corn Belt region of the United States with area studied—1970*



Sampling Procedures

During the late summer of 1970, a total of 400 sites were sampled in the Corn Belt region. These were selected from the 13,300 cropland and noncropland sample sites already designated for the National Soils Monitoring Program, one-fourth of which are sampled each year. The complete sampling scheme for the National Soils Monitoring Program has been reported by Wiersma, Sand, and Cox (*3*).

Fifty soil cores, each 2 inches in diameter by 3 inches in depth, were collected in a grid pattern over each 10-acre sampling site, composited, and passed through a ¼-inch sieve. A 2-qt metal container was filled from each composite sample, sealed, and shipped to the monitoring laboratory at Gulfport, Miss., for residue analyses.

Crops growing on sites at the time of sampling were collected simutaneously with the soil, i.e., as each soil core was taken, a nearby sample of the standing crop was also taken. The crop samples from each site were composited, air-dried, and packed for shipment to the laboratory. Hay and forage were packed in plastic bags, while corn grain, sorghum grain, and soybeans were packed in 2-qt metal containers.

Analytical Procedures

PREPARATION OF SAMPLES

Soil

A 300-g sample of soil plus 80 ml of water used to wet the soil was extracted with 600 ml of 3:1 hexane isopropanol by concentric rotation for 4 hours. The alcohol was removed by three water washes, and the hexane extract was dried through anhydrous sodium sulfate. The sample extract was then stored at low temperature for subsequent gas-liquid chromatographic analysis.

Crops

For crop samples containing less than 2% fat (cornstalks, sorghum fodder, and mixed hay), a 100-g sample plus 25 ml of distilled water was blended for 3 minutes in 800 ml of acetonitrile. One-half the sample extract, representing 50 g of original sample, was decanted into a 500-ml graduated cylinder and then transferred to a 500-ml Erlenmeyer flask. After concentration under a three-ball Snyder column to approximately 10 ml, 100 ml of hexane was added, and the hexane-acetonitrile azeotrope was again concentrated to 10 ml. Addition of hexane and concentration to 10 ml were carried out three times to remove essentially all the

acetonitrile. The hexane extract was dried through anhydrous sodium sulfate, the volume adjusted to 100 ml, and the extract stored at low temperature until ready for partitioning.

For crop samples containing more than 2% fat (corn, sorghum grain, and soybeans), a 100-g sample was prewashed with 100 ml of isopropanol and 100 ml of hexane, in that order, and the prewashes discarded. The sample was dried and then dry-blended; 100 ml of isopropanol was added, and the sample was blended again. After the addition of 300 ml of hexane, the isopropanol was removed by two washes with aqueous NaCl solution and one wash with distilled water. The water-alcohol layers were discarded, and the hexane layer was concentrated, adjusted to 100 ml, and held at low temperature for partitioning.

After the above extraction procedure, all crop samples were partitioned with hexane-acetonitrile as follows: a 50-ml portion of the hexane sample extract was shaken with 100 ml of acetonitrile in a 500-ml separatory funnel. The bottom acetonitrile layer was saved. Nanograde acetonitrile (100 ml) was added to the hexane extract, and the separation step above was repeated twice more; then, the hexane was discarded and the three acetonitrile layers combined. The 300-ml acetonitrile extract, which contained essentially all the pesticides in the original hexane extract, was backwashed with 25 ml of acetonitrile-saturated hexane and the hexane layer discarded. The acetonitrile sample extract was concentrated to approximately 10 ml under a three-ball Snyder column, and 100 ml of hexane was added. The addition of hexane and concentration to approximately 10 ml were carried out three times after which the sample was essentially in hexane. The hexane extract was diluted to appropriate volume and held at low temperature for subsequent Florisil column cleanup and fractionation.

GAS-LIQUID CHROMATOGRAPHY

Analyses were performed on gas chromatographs equipped with tritium foil electron affinity detectors for organochlorine compounds and thermionic or flame photometric detectors for organophosphorous compounds. A multiple-column system employing polar and nonpoplar columns was utilized to identify and confirm pesticides. Instrument parameters were as follows:

Columns:	Glass, 6 mm o.d. x 4 mm i.d., 183 cm long, packed with one of the following: 9% QF-1 on 100/120 mesh Gas-Chrom Q; 3% DC-200 on 100/120 mesh Gas-Chrom Q; or 1.5% OV-17/1.95% QF-1 on 100/120 mesh Supelcoport
Carrier gases:	5% methane-argon at a flow rate of 80 ml/min; prepurified nitrogen at a flow rate of 80 ml/min
Temperatures:	Detector 200° C Injection port 250° C Column QF-1 166° C Column DC-200 170°-175° C Mixed column 185°-190° C

Sensitivity (minimum detectable levels) for organochlorine compounds ranged from 0.002 ppm to 0.03 ppm except for mixtures of polychlorinated biphenyls (PCB's), chlordane, toxaphene, etc. whose minimum detectable levels were 0.05 to 0.1 ppm. Minimum detectable levels for organophosphorous compounds were approximately 0.01 to 0.03 ppm. When necessary, confirmation of residues was made by thin layer chromatography or p-values.

Arsenic

Arsenic was determined by atomic absorption spectrophotometry. The soil sample was first extracted with 9.6N hydrochloric acid (HCl) and reduced to trivalent arsenic with stannous chloride. The trivalent arsenic was partitioned from HCl solution to benzene, then further partitioned into water for the absorption measurement. A Perkin-Elmer Model 303 instrument was used and absorbance measured with an arsenic lamp at 1972 Å with argon as an aspirant to an air-hydrogen flame. The minimum detection limit was 0.10 ppm.

RECOVERY STUDIES

For organochlorine pesticides, the average recovery rate in soil was 90% to 110%. Recovery values for stalks and hay ranged from 80% to 95% with an average of 89%; corresponding values for grains were 90% to 100% with a 95% average. For organophosphate pesticides, the average recovery values were 67.1% for soybeans, 86% for sorghum grain, and 60% for corn stalks. Recovery values for arsenic ranged from 70% to 80%. All residue levels were corrected for percent recovery.

Results

PESTICIDE USE RECORDS

The pesticide-use information, as reported by the farmers, was divided into five categories:

	Percent of Sites
(1) No pesticides used in 1970, or in the 5 years prior to 1970	15.5
(2) No pesticides used in 1970, but used in the 5 years prior to 1970	15.5
(3) Pesticides used in 1970 and in the 5 5 years prior to 1970	53.2
(4) Pesticides used in 1970 only, none in the 5 years prior to 1970	4.8
(5) No use records available	11.0

These data indicate that pesticides had been applied to most of the agricultural acreages sampled in the Corn Belt (up to 85%). Although pesticides reportedly had not been applied in 1970 or the past 5 years on 15.5% of the sites, many of the samples taken from these sites contained pesticide residues; however, this is not unusual. Probable explanations include inaccurate record keeping, spray drift, and the persistent nature of many of the compounds.

Table 1 lists the pesticides used in 1970 on the sample sites, the average application rate, and the number of sites where applied. Table 1 should be considered a conservative estimate of the amounts of pesticides applied to the study areas. In most cases, farmers were most certain of the kinds and amounts of pesticides they had used for the current cropping season. However, in a few cases, farmers knew neither the names nor the amounts of pesticides used on their crops.

The use of unknown seed dressings was common, particularly in Nebraska. Since captan and malathion were indicated as being used almost exclusively as seed dressings, it is likely that they were the "unknown" seed dressings in many cases. Hence their estimates in Table 1 may be particularly low.

TABLE 1.—*Pesticides used on sampling sites in the Corn Belt region of the United States during 1970 growing season, average application rate, and number of sites where applied*

Compounds Applied	Average Application Rate (lb/acre)	Number of Sites Where Applied
Alachlor	1.22	15
***Aldrin**	1.30	27
Amiben	1.08	29
Atrazine	1.51	78
Borax	1.50	1
Butylate (Sutan)	1.10	3
Buxten	1.88	15
***Captan**	.03	68
Carbaryl	1.93	6
CDAA	.80	1
Ceresan	.01	1
Chloropropham (CIPC)	.25	2
2,4-D	.55	55
2,4-DB	.50	1
***DDT**	2.00	1
***Diazinon**	1.34	5
***Dicamba**	.94	5
***Dieldrin**	.01	2
***Disulfoton**	.74	5
***Dyfonate**	1.00	1
***Fensulfothion**	.80	1
***Fenthion**	2.50	2
Furadan	.85	2
***Heptachlor**	.19	8
Knoxweed	.35	2
***Lindane**	.10	4
Linuron	2.22	5
***Malathion**	.02	58
MCPB	2.00	1
***Methoxychlor**	.01	5
***Nitralin**	.50	1
Norea	.67	3
NPA	.40	2
Panogen	.01	1
***Parathion**	.40	4
***Phorate**	2.04	13
***Propachlor** (Ramrod®)	2.10	31
Propazine	1.60	1
2,4,5-T	.50	1
***Trifluralin**	.64	15

* Compounds detectable by described methodology.

In all, 40 different compounds were used: 20 herbicides, 17 insecticides, and 3 fungicides. Atrazine was most widely used, followed by captan, malathion, 2,4,-D, propachlor (Ramrod®), amiben, and aldrin. Fenthion was applied most heavily, with an average application rate of 2.5 lb/acre. Although the list of compounds in Table 1 is lengthy, approximately 68% of all the compounds listed were used on five or less sites; 30% of the compounds on the list were used on only one site.

RESIDUES DETECTED IN SOIL

Pesticide residues were detected in 45% of the soil samples analyzed, and 11 pesticides or metabolites were identified. Arsenic, which can occur naturally in soil, was detected in nearly all soil samples. The analytical methods employed were able to detect only 45% of the compounds listed in Table 1 and these are indicated in the table; however, most of the widely used pesticides were included in this group.

Table 2 shows the arithmetic means and ranges of residue levels in soil from each State as well as the percent of positive samples for each compound. The most commonly detected residues were those of dieldrin, aldrin, and chlordane. Since very little dieldrin was used in the study area and the use records indicated that aldrin had been used frequently in the past, most of the dieldrin detected has undoubtedly metabolized from aldrin.

Although chlordane residues were found in soil samples from 7 of the 12 States sampled (approximately 17% of the samples analyzed), no chlordane applications were indicated on any of the use records for 1970 or for the 5 years prior to 1970. Four DDT metabolites (*p,p'*-DDE, *o,p'*-DDT, *p,p'*-DDT, and *p,p'*-TDE) were indentified and are listed together as DDTR in Table 2.

Both endrin and isodrin were detected in about 1% of the samples analyzed, but the use records do not indicate that these compounds were applied in 1970 or in previous years. Endrin is currently registered for use on corn and sorghum grain. Since endrin and isodrin are chemically similar to aldrin and dieldrin, it is likely that the small amounts detected have come from the parent compounds. Also, since endrin, isodrin, and chlordane are persistent compounds (*4*), the amounts detected could have been present from application prior to 1965 or may represent unreported usage.

RESIDUES DETECTED IN CROPS

The crops sampled in the study and the residues detected are listed in Table 3. Seven compounds, including the four DDT metabolites listed above, were detected. The greatest number of residues were detected in cornstalk samples. Approximately 20% of all the cornstalk samples contained pesticide residues; however, no residues were detected in corn grain samples from the same sites.

TABLE 2.—*Organochlorine and arsenic residues in soil from the 12 States in the Corn Belt region of the United States—1970*
[ND = not detected]

STATE	NO. OF SAMPLING SITES	ALDRIN	CHLORDANE	DIELDRIN	ENDRIN	HEPTACHLOR	HEPTACHLOR EPOXIDE	ISODRIN	TRIFLURALIN	DDTR	ARSENIC
Illinois	69										
Range of detected residues (ppm)		0.01-0.83	0.05-1.32	0.01-1.08	ND	0.01-0.18	0.01-0.09	0.01	0.01-0.08	0.06-0.12	0.10-3.60
Average (ppm)		0.07	0.09	0.14		0.01	0.01	<0.01	<0.01	<0.01	1.15
No. of positive samples [1]		24	16	46		10	16	1	5	2	63
Percent positive sites [2]		34.8	23.2	66.7		14.5	23.2	1.4	7.2	2.9	91.3
Indiana	36										
Range of detected residues (ppm)		0.02-2.41	0.29-4.30	0.01-2.04	0.02	0.27	0.03-0.15	0.08	ND	0.06	0.20-14.00
Average (ppm)		0.15	0.20	0.13	<0.01	0.02	0.01	<0.01		<0.01	4.15
No. of positive samples [1]		10	3	14	1	1	2	1		1	36
Percent positive sites [2]		27.8	8.3	38.9	2.8	2.8	5.6	2.8		2.8	100.0
Iowa	76										
Range of detected residues (ppm)		0.01-2.98	0.17-3.35	0.01-1.03	0.02	0.01-0.84	0.02-0.31	0.02-0.06	0.02-0.06	0.01-3.07	0.10-6.10
Average (ppm)		0.08	0.13	0.10	<0.01	0.02	0.01	<0.01	<0.01	0.07	1.36
No. of positive samples [1]		21	11	42	1	6	11	2	3	8	52
Percent positive sites [2]		27.6	14.5	55.3	1.3	7.9	14.5	2.6	3.9	10.5	68.4
Kansas	28										
Range of detected residues (ppm)		0.11	0.32-0.54	0.09-0.21	ND	0.02	0.09	ND	ND	ND	0.20-6.40
Average (ppm)		0.01	0.03	0.02		<0.01	<0.01				1.55
No. of positive samples [1]		1	2	3		1	1				28
Percent positive sites [2]		3.6	7.1	10.7		3.6	3.6				100.0
Kentucky	1										
Range of detected residues (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	ND	5.50
Average (ppm)											5.50
No. of positive samples [1]											1
Percent positive sites [2]											100.0
Michigan	14										
Range of detected residues (ppm)		ND	ND	0.01	ND	ND	ND	ND	ND	0.01	0.20-11.40
Average (ppm)				<0.01						<0.01	4.42
No. of positive samples [1]				1						1	14
Percent positive sites [2]				7.1						7.1	100.0

TABLE 2.—*Organochlorine and arsenic residues in soil from the 12 States in the Corn Belt region of the United States—1970*—Continued
[ND = not detected]

State	No. of Sampling Sites	Aldrin	Chlordane	Dieldrin	Endrin	Heptachlor	Heptachlor epoxide	Isodrin	Trifluralin	DDTR	Arsenic
Minnesota	37										
Range of detected residues (ppm)		0.05-0.21	0.87	0.08-0.60	ND	ND	0.17	ND	0.09-0.33	ND	0.90-10.80
Average (ppm)		0.01	0.02	0.05			<0.01		0.02		3.58
No. of positive samples [1]		3	1	8			1		3		36
Percent positive sites [2]		8.1	2.7	21.6			2.7		8.1		97.3
Missouri	31										
Range of detected residues (ppm)		0.04-0.45	0.14-0.53	0.01-0.66	ND	0.75	0.02-0.05	ND	0.03	ND	0.50-11.50
Average (ppm)		0.04	0.02	0.05		0.02	<0.01		<0.01		3.84
No. of positive samples [1]		5	2	10		1	2		1		31
Percent positive sites [2]		16.1	6.4	32.3		3.2	6.4		3.2		100.0
Nebraska	47										
Range of detected residues (ppm)		ND	ND	0.01-0.22	0.02	0.02	0.01-0.05	ND	ND	0.10-2.30	0.20-11.90
Average (ppm)				0.02	<0.01	<0.01	<0.01			0.05	1.73
No. of positive samples [1]				20	1	1	5			2	33
Percent positive sites [2]				42.6	2.1	2.1	10.6			4.3	70.2
Ohio	29										
Range of detected residues (ppm)		0.02-0.45	ND	0.01-0.45	ND	ND	ND	ND	0.08	ND	0.70-22.75
Average (ppm)		0.03		0.04					<0.01		6.41
No. of positive samples [1]		4		7					1		29
Percent positive sites [2]		13.8		24.1					3.4		100.0
South Dakota	26										
Range of detected residues (ppm)		ND	ND	0.09-0.16	0.04	ND	ND	ND	ND	0.02	0.70-7.70
Average (ppm)				0.01	<0.01					<0.01	2.54
No. of positive samples [1]				2	1					2	26
Percent positive sites [2]				7.7	3.8					7.7	100.0
Wisconsin	5										
Range of detected residues (ppm)		0.01	0.05	0.21	ND	ND	ND	ND	ND	ND	1.40-4.80
Average (ppm)		<0.01	0.01	0.04							2.00
No. of positive samples [1]		1	1	1							4
Percent positive sites [2]		20.0	20.0	20.0							80.0

NOTE: Total number of sampling sites used for statistical treatment was 399. One sampling site from Nebraska was omitted.

[1] One sample per site.

[2] Percent based on number of samples with residues greater than or equal to the sensitivity limits.

TABLE 3.—*Residues in crops from the 12 States in the Corn Belt region of the United States—1970*
[ND = not detected]

Crop	No. of Samples [1]	Dieldrin	Heptachlor epoxide	*p,p'*-DDE	*p,p'*-DDT	*o,p'*-DDT	*p,p'*-TDE	DDTR	Ethyl parathion	PCB's
Corn	147	Not detected								
Cornstalks	145									
Range of detected residues (ppm)		0.01-0.04	ND	0.01-0.13	0.01-7.04	0.01-0.51	0.01-0.16	0.01-7.84	0.25	0.53-6.25
Average (ppm)		<0.01		<0.01	0.05	<0.01	<0.01	0.06	<0.01	2.80
No. of positive samples		14		2	3	2	2	3	1	10
Percent positive samples [2]		9.7		1.4	3.4	1.4	1.4	3.4	0.7	6.9
Soybeans	75									
Range of detected residues (ppm)		0.01-0.08	0.02-0.03	ND	ND	ND	ND	ND	ND	ND
Average (ppm)		0.01	<0.01							
No. of positive samples		42	2							
Percent positive samples [2]		56.0	2.7							
Sorghum grain	24	Not detected								
Sorghum fodder	21									
Range of detected residues (ppm)		0.01	ND	ND	ND	ND	ND	ND	ND	ND
Average (ppm)		<0.01								
No. of positive samples		1								
Percent positive samples [2]		4.8								
Mixed hay	11									
Range of detected residues (ppm)		ND	ND	ND	ND	ND	ND	ND	ND	0.80-2.94
Average (ppm)										0.57
No. of positive samples										3
Percent positive samples [2]										27.3

[1] Represents composite samples of available standing crops collected simultaneously with soil samples.
[2] Percent based on number of samples with residues greater than or equal to the sensitivity limits.

This selective translocation of residues has been observed in other studies (*5*). The DDTR residues were found in stalk samples from Indiana, Iowa, and Missouri.

Only residues of dieldrin and heptachlor epoxide were found in soybean samples, with 56.0% and 2.7%, respectively, of the samples containing residues. At this time, the tolerance for dieldrin residues in soybeans is zero (*6*), and the tolerance for combined heptachlor and heptachlor epoxide residues in soybeans has not been established. The sampling may have occurred shortly after an application, and the residues might have been zero if the proper time interval had been observed. Low levels (<0.01 ppm) of dieldrin residues also were detected in sorghum fodder. Crop samples from sites for which records showed usage of organophosphate pesticides in 1970 were analyzed for these compounds; however, only one sample was positive (0.25 ppm ethyl parathion).

In addition to pesticide residues in the crops, two PCB compounds, identified as Aroclor 1232® and 1242®, were also detected. The PCB's were identified by comparing retention times of multiple peaks from sample chromatograms to the corresponding multiple peaks from standard chromatograms of the various PCB's. This type of comparison was made on at least two columns of different polarities. Quantitation was based on comparison of the summation of peak height units from the sample chromatogram. At least three peaks were used for quantitation. Standard PCB's were run at least once daily and usually twice or more. The PCB's were found in cornstalk and hay samples from 6 of the 12 States (Ohio, Indiana, Michigan, Illinois, Iowa, and Missouri) but were not detected in corn grain, soybeans, or sorghum. The source of the PCB's has not yet been positively identified but is still under investigation.

Discussion

The presence of residues in crop samples is probably a result of their absorption and translocation to various plant parts. Evidence of translocation of residues has been found in corn (*5*), soybeans (*8-10*), alfalfa (*10*), carrots (*14*), potatoes (*14,15*), turnips (*8*), and pea-

nuts (*8*). Corn plants have been shown to accumulate dieldrin residues largely in the leaves (*5*). Crops grown in aldrin-treated soils have been found to contain both aldrin and dieldrin (*7*).

No trends concerning the pesticide residue levels in agricultural soils of the Corn Belt region can be clearly identified from these data. Pesticides have been widely used throughout the region (on 75% to 85% of the sites sampled), but organochlorine residues in soil were found in less than half of the areas. The ability of a particular soil to retain and/or release pesticide residues is greatly influenced by the interaction between the physical and chemical properties of both the soil and the pesticides applied as well as the microfloral and microfaunal components of the soil system. In general, soils high in organic matter or clay content tend to retain pesticide residues longer than sandy soils or soils low in organic matter (*7,10-13,16*); this retention ability appears to be most positively correlated with organic matter content. Initial concentration and the formulation of the pesticide are also important. The degradation rate does not remain constant but decreases logarithmically as dosage increases. Sprays tend to disappear sooner than dusts because of a faster initial volatilization, although loss from drift is significant for dusts.

In addition, different crops absorb pesticide residues from the soil at varying rates (*5,7,8,14*). In this study almost 20% of all crop samples contained detectable residue levels. Future studies should aim for a more comprehensive correlation among soil properties, soil residue levels, and translocation potentials of particular crops.

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See Appendix for chemical names of compounds discussed in this paper.

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GENERAL

Decay of Parathion Residues on Field-Treated Tobacco, South Carolina—1972 (II)

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ABSTRACT

In an effort to confirm the results of a study in 1971 to determine the length of time required for parathion to degrade to "zero" levels, parathion was applied twice at a rate of .375 lb/acre to field tobacco in South Carolina. After each application, parathion degraded to "zero" levels in 5 days. These results tended to confirm the findings of the original study in which the maximum time required for parathion to degrade to zero levels was estimated to be 7 days and the minimum time 2 days. Weather was characterized by scanty rainfall and temperatures averaging 76° F. During the original study, rainfall was heavy and daily temperatures averaged 80.9° F.

Introduction

A study reported by Keil *et al.* (*1*) was carried out in June-July 1971 to observe the decline with time of levels of parathion normally applied to field tobacco. This paper reports the results of a second study conducted in June-July 1972 to confirm the findings of the 1971 study.

Methods and Procedures

All growing, application, sampling, and analytical techniques were identical to those of the earlier study (*1*). Cokers 319 variety tobacco was planted on April 17, 1972. Plots consisting of three 12-foot rows were randomly selected for treatment with parathion, endosulfan, parathion in combination with endosulfan, or as appropriate controls. Each treatment or control plot was replicated four times in a completely randomized design for a total of 16 plots. Guard rows were used to reduce pesticide drift. In the earlier study, parathion and endosulfan were applied as sprays at rates of .375 and .125 lb active ingredient (A.I.) per acre, respectively, on June 8, 21, and July 8, 1971. In the present study, parathion and endosulfan were sprayed at these same rates on both June 12 and 28, 1972.

Results and Discussion

Results of analyses for parathion residues are given in Table 1 and indicate that parathion residues decayed to "zero" levels in 5 days after each application. Practical "zero" was assumed when statistical differences between actual zero (none detected) and observed values did not exceed the calculated LSD (least significant difference at the .05 level). The results tended to confirm the findings of the original study in 1971 in which the maximum time required for parathion to degrade to zero levels was estimated to be 7 days and the minimum time 2 days.

Endosulfan residues were not measured, but tobacco from the endosulfan-treated plots was analyzed for parathion to determine if there was a measurable amount of drift between plots. The parathion-endosulfan treatment was included to determine if any decay interaction existed between the two chemicals. This was noted at one sampling period, 1 day after application, i.e., more parathion residue was present when parathion-endosulfan was applied. This effect was noted in the previous study up to and including the third day after application.

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Weather during the 1972 study was characterized by scanty rainfall and temperatures averaging 76° F (Table 2). In the 1971 study, rain had been in excess of 12 inches and daily temperatures averaged 80.9° F. Results of both studies support the findings of Maier-Bode (*2*) who concluded that rainfall does not significantly affect residue levels of parathion.

See Appendix for the chemical names of compounds discussed in this paper.

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LITERATURE CITED

(*1*) *Keil, J. E., C. B. Loadholt, B. L. Brown, S. H. Sandifer, and W. R. Sitterly. 1972.* Decay of parathion and endosulfan residues on field-treated tobacco, South Carolina—1971. Pestic. Monit. J. 6(1):73-75, Erratum (This issue).

(*2*) *Maier-Bode, H. 1970.* Parathion residues. Dtsch. Med. Wochenschr. 95(48):2457.

TABLE 1.—*Parathion residues on field-treated tobacco by treatment plots, South Carolina—1972*

Application Date	Sampling Time in Days from Last Application	Mean Parathion Residue Level in PPM on Four Replicate Treatment Plots			
		Parathion—Treated Plot (.375 A.I. lb/acre)	Endosulfan—Treated Plot (.125 A.I. lb/acre)	Parathion (.375 A.I. lb/acre)/ Endosulfan (.125 A.I. lb/acre)—Treated Plot	Control Plot
June 12	0	0	0	0	0
	1	1.30	.21	3.37	.05
	3	.46	.05	.26	.03
	5	.03	.01	.09	0
	10	0	0	0	0
	15	0	0	0	0
June 28	1	1.98	.29	1.54	.05
	3	.48	.02	.13	.02
	5	.07	0	0	0
	9	0	0	0	0
	15	0	0	0	0

NOTE: LSD_{05} = lease significant difference at 95% probability level = .50 and may be applied across time or residues.

TABLE 2.—*Temperature and rainfall during parathion residue degradation*

Period	Time to "Zero" Residue [1]	Temperature (°F) Lows	Highs	Avg.[2]	Rainfall (inches)
June 12-17	5 days	50-67	80-87	72	0
June 28-July 3	5 days	68-70	87-93	80	(July 1) 1.08

[1] "Zero" residue level was assumed when statistical differences between actual zero (none detected) and observed values did not exceed the calculated LSD (least significant difference at the .05 level).
[2] Overall average temperature, 76° F.

Pesticide Sales and Usage in Kentucky—1968[1]

E. Edsel Moore

ABSTRACT

In Kentucky during 1968, 135 pesticide compounds were applied for agricultural and nonagricultural use in a volume of approximately 3.9 million pounds technical material (excluding most pesticides formulated for home, lawn, and garden use). This amounted to about 0.5% of the Nation's total consumption of pesticides. The pesticide poundage used in Kentucky, of which 67% was herbicides, was applied to an estimated 1 million acres, 4% of the State's land. This included over 900,000 lb of herbicides applied to rights-of-way throughout the State by various utility companies. Fourteen of the 135 base compounds sold constituted 73.3% of the total poundage used. These included, in order of volume, methyl bromide, maleic hydrazide, atrazine, DDT, 2,4-D, chlordane, sulfur, copper sulfate, aldrin, sodium chlorate, TDE, carbaryl, malathion, and methoxychlor.

Introduction

In the United States, the manufacture of pesticides is now a billion dollar industry which began its expansion with the introduction of synthetic organic pesticides during the mid-1940's. Modern public health programs and farm production practices are dependent on pesticides. Countless lives have been saved in this country and abroad by the use of pesticides for control of vector-borne diseases. In the United States, the use of pesticides has been an important factor in improving the quality and yield of farm products and has contributed significantly to the annual increase in farm income.

At present, some 60,000 pesticide formulations, containing 1 or more of 900 active pesticide chemicals (*1*), are available for use as insecticides, herbicides, fungicides, rodenticides, and plant growth regulators. These are packaged in numerous forms and may be purchased at a variety of retail outlets.

The usage patterns of pesticides—past, present, and future—have the potential for profoundly influencing the environment and, consequently existing as well as future pesticide monitoring programs. The purpose of the survey reported in this paper was to outline the patterns of pesticide sales and usage in Kentucky during 1968. To compile the principal pesticide sales and usage data for Kentucky, the following sources were contacted: (1) in-State sales outlets for the pounds of technical materials sold in the State and (2) aerial applicators, utility companies, and State agencies for types and amounts of pesticides used, number of acres treated, and sources of pesticides purchased.

Background Information

Although Kentucky is developing industrially, it is still a rural State. In 1960, Kentucky had a population of 3,038,156, of whom 55% resided in rural areas (*2*). The boundaries of the State encompass an area of 40,395 square miles or 25,852,800 acres. Nationally, Kentucky ranked 22d and 37th in population and land area, respectively. In 1964, acreage classified as farmland totalled 16,265,180 acres, of which 9,364,980 acres were considered cropland (*3*); there were approximately 133,000 farms averaging 123 acres in size.

Kentucky's economy depends heavily on agriculture. Economically, tobacco is Kentucky's most important

[1] From the Pesticides Program, Division of Environmental Services, State Department of Health, Frankfort, Ky. 40601.

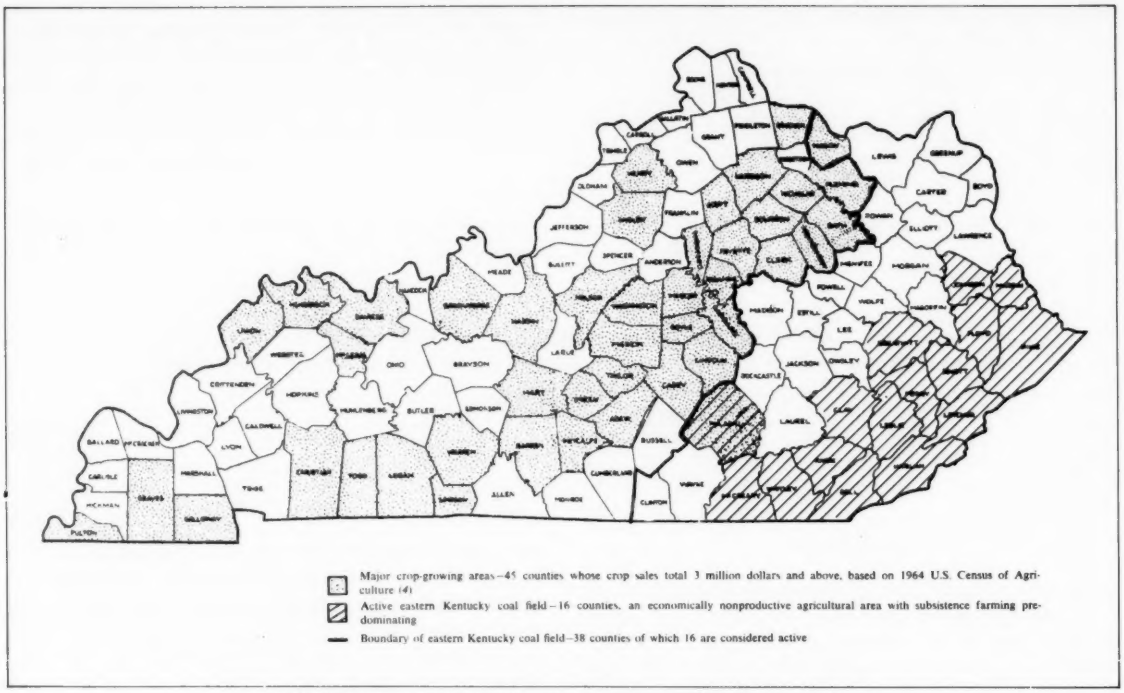
Major crop-growing areas—45 counties whose crop sales total 3 million dollars and above, based on 1964 U.S. Census of Agriculture (4)
Active eastern Kentucky coal field—16 counties, an economically nonproductive agricultural area with subsistence farming predominating
Boundary of eastern Kentucky coal field—38 counties of which 16 are considered active

FIGURE 1.—*Agricultural activity by county, Kentucky—1964*

farm commodity, providing one-third of the agricultural income, followed by the sale of livestock and the dairy industry. Most of this farm income is derived from central, northern, and western areas. The Eastern Kentucky Coal Field area includes 38 counties, with 16 counties comprising the active coal mining area (Fig. 1) (Div. of Strip Mining and Reclamation, Kentucky State Dep. of Natural Resources, Frankfort 1969, *personal communication*). Due to its topography, this entire area, with the exception of two counties, is a nonproductive agricultural region, with subsistence farming predominating.

In Kentucky, since 1961, approximately 3.7 million acres of crops have been harvested each year; principal crops have included corn, hay, soybeans, small grains, and tobacco (Table 1) (*3*). Since 1960, the total crop acreage has not fluctuated more than 1%; there have been, however, changes in the acreages planted to specific crops.

During an 8-year period from 1960-1968, the overall agricultural gross product increased from 560 million dollars to well over 910 million dollars (U.S. Dep. of Agric. Statistical Reporting Service, Louisville Branch Off., 1969, *personal communication*), an amount approaching one-third of the State's total gross product. This can be attributed, in part, to a greater shift towards beef cattle, swine, and grain production, particularly

TABLE 1.—*Crops harvested in Kentucky, 1967*

Crops	Approximate Acreage Harvested
Corn	1,218,000
Popcorn	19,000
Hay	
Clover and Timothy	616,000
Lespedeza	415,000
Alfalfa	383,000
Other	275,000
Soybeans	310,000
Small grains (wheat, barley, oats, and rye)	247,000
Tobacco	177,000
Fruits and Vegetables	11,000
Miscellaneous	30,000
Total	3,701,000

west of a line extending north and south from Jefferson County to Monroe County and west to the Mississippi River. This area encompasses some 45 to 50 counties. Secondly, Kentucky is a major producer of milk and dairy products, and this industry is increasing. In 1968, nationally, Kentucky ranked 13th in milk production and 2d and 7th in production of evaporated milk and cheese, respectively. In addition, pesticide usage is responsible for a significant portion of this increase.

PESTICIDE LEGISLATION

In 1968, Kentucky was one of 47 States that had a pesticide registration law; currently all 50 States have registration laws. Kentucky does not, however, have a law that specifies the reporting of pesticide sales or usage. The State laws and regulations that apply to pesticides are presented in Table 2. In 1968, results of a questionnaire survey (conducted by mail by the Kentucky State Department of Health) showed that the 40 largest cities in Kentucky (4,000 population and above, based on 1960 census figures) had no laws, codes, or ordinances applicable to pesticides on the local level.

METHODS OF APPLICATION

In Kentucky, ground application is the most common method of applying pesticides. Several different types of equipment are used, the most common being the self-propelled "highboy" (a tri-wheeled vehicle with 5-6 ft clearance, the principal application equipment used in the tobacco-growing areas) and the tractor-drawn trailer rig or tractor-mounted spray boom. An estimated 1,500 highboys were in use in 1968 (Kentucky Distributors of Highboys, *personal communication*). In the principal fruit- and vegetable-growing areas, powered speed and row-crop sprayers are the most widely used methods of application. Dust application is diminishing and constitutes only a small portion of the total pesticide usage for all commercial agricultural crops.

Aerial application of pesticides is not a thriving enterprise in Kentucky as it is in the Great Plains States because of the small size and inaccessibility of fields to be treated; this is evidenced by the small number of operators licensed in 1968, 8 compared with 12 in 1960 (Kentucky Dep. of Aeronautics, *personal communication*). In 1968, application by two operators was confined to weed and brush control on rights-of-way of various utility companies, principally in 12 southeastern Kentucky counties (Fig. 2). The total acreage in Kentucky treated for all purposes by aerial application was approximately 14,000 acres.

Pesticide Use Patterns

AGRICULTURAL USAGE

In Kentucky, pesticide usage generally begins in March with application to peaches, apples, and alfalfa and continues until late August or early September, depending on the growing season within the State. The peak periods are usually in April, May, and June (Table 3), with an estimated 85%-90% of the pesticide applications occurring from April through August.

Data abstracted from 1964 U.S. Census of Agriculture (*4*) indicated that 1.21% of the farmland in Kentucky or 196,808 acres were treated for insect and disease control, and 2.69% or 437,533 acres were treated for

TABLE 2.—*State laws and regulations applicable to pesticides, Kentucky—1968*

State Laws and Regulations	Agency Responsible for Administration and Enforcement	Explanation of Law or Regulation
REGISTRATION AND LABELING LAWS		
Eonomic Poison Law—1956 Kentucky Revised Statutes Chapters 217.540 to 217.640	Division of Regulatory Services University of Kentucky	Requires the registration of all substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, fungi, bacteria, weeds, or other forms of plant or animal life or virus (except viruses on or in living man or other animals) which are declared to be a pest.
Food, Drug and Cosmetic Act—Revised 1960 Kentucky Revised Statutes Chapters 217.005 to 217.215, 217.992	Division of Environmental Services State Department of Health	A section of this act requires that pesticide residues on or in raw agricultural products must comply with tolerances established by the U.S. Food and Drug Administration provided a tolerance has been established.
USE AND APPLICATION LAW		
Termite and Pest Control Industry Law—1954, Revised 1960 as the Kentucky Structural Pest Control Act Kentucky Revised Statutes Chapters 249.250 to 249.340, 249.990	Division of Noxious Weed and Pest Control State Department of Agriculture	Basically, requires the licensing of all pest control operators by the State Department of Agriculture. Applicants must pass an examination to secure a license.
REGULATIONS		
Aerial Applicators Regulation—1952 KAV-5-2 to KAV-5-10 Kentucky Revised Statutes Chapter 183	State Department of Aeronautics	Requires the licensing of all aircraft engaged in commercial aerial application.
Occupational Health Regulations—1963, Revised 1966 Kentucky Revised Statutes Sections 211.080, 211.180	Division of Occupational Health State Department of Health	Requires compliance with threshold limit values established for pesticides in the atmosphere in pesticide and chemical manufacturing and formulating plants.

NOTE: In 1972, Kentucky enacted a pesticide use and application act—"Kentucky Pesticide Use and Application Act of 1972" (Ky. Rev. St. 1972 s217B.010 to s217B.099).

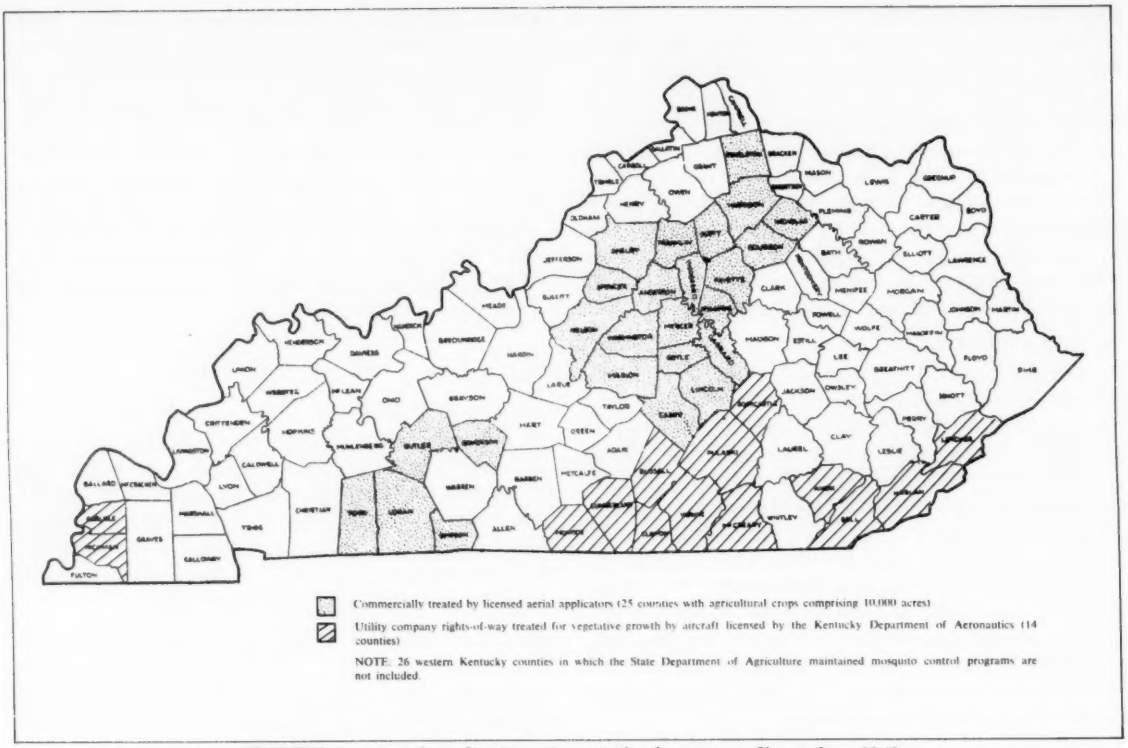
Commercially treated by licensed aerial applicators (25 counties with agricultural crops comprising 10,000 acres)
Utility company rights-of-way treated for vegetative growth by aircraft licensed by the Kentucky Department of Aeronautics (14 counties)
NOTE: 26 western Kentucky counties in which the State Department of Agriculture maintained mosquito control programs are not included.

FIGURE 2.—*Aerial application of pesticides by county, Kentucky—1968*

TABLE 3.—*General agricultural and nonagricultural pesticide usage by months, Kentucky*

Pesticide Usage	Application Period											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
AGRICULTURAL CROPS AND FIELDS												
Fruits (excluding dormant)			X	X	X	X	X	X	X			
Vegetables (excluding greenhouse-grown)					X	X	X	X	X			
Corn												
Soil				X	X							
Crop						X	X	X				
Alfalfa			X	X	X	X						
Tobacco												
Soil (excluding tobacco beds)				X	X							
Crop					X	X	X	X				
Small grains				X	X							
Soybeans				X	X	X						
Pasture (Thistle control)			X	X	X							
NONAGRICULTURAL USAGE												
Mosquitoes				X	X	X	X	X	X			
Rights-of-way					X	X	X	X				
Johnson grass				X	X	X						

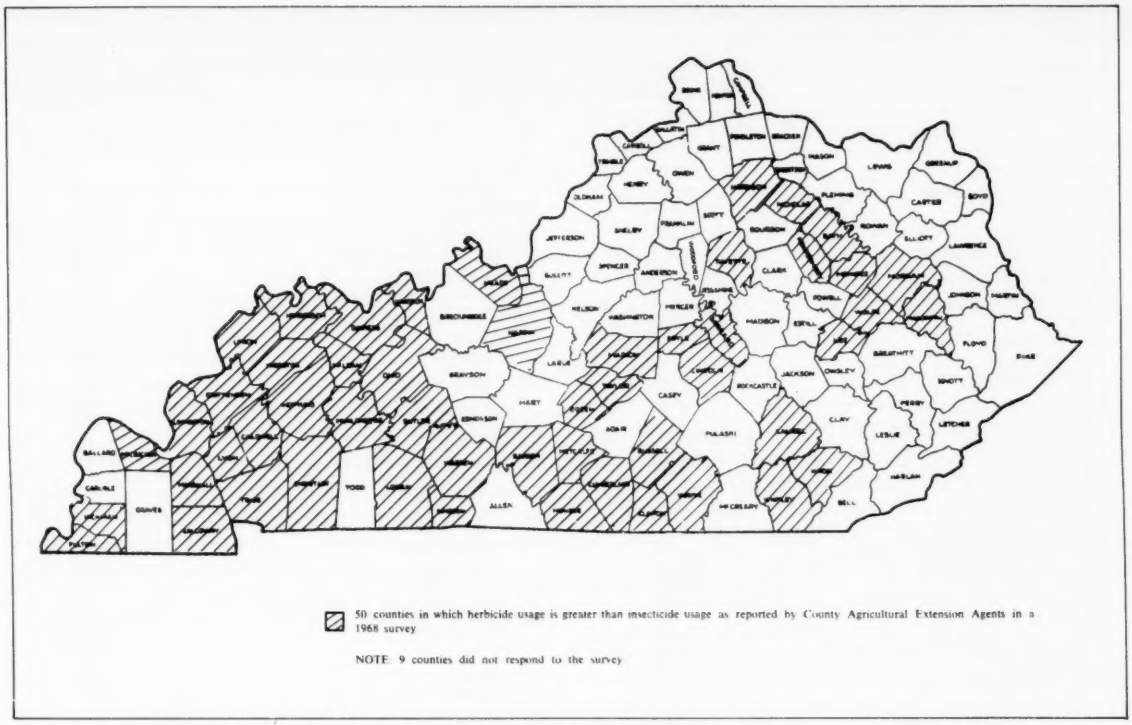
50 counties in which herbicide usage is greater than insecticide usage as reported by County Agricultural Extension Agents in a 1968 survey
NOTE: 9 counties did not respond to the survey

FIGURE 3.—*Counties in which herbicide usage is greater than insecticide usage, Kentucky—1968*

weed control. Nationally, Kentucky ranked 40th and 35th, respectively, in each category of treatment. By comparison, although the total acreage is small, New Jersey ranked first in the Nation with 13.9% of its farmlands being treated for insect and disease control, and Delaware ranked first in weed control, treating 21.42% of its farmland.

Responses from 111 of Kentucky's 120 County Agents to a questionnaire survey indicated that an estimated 89% of the farmers in Kentucky used some type of pesticide material in 1968. Fifty agents estimated that farmers in their counties used more herbicides than insecticides; these were primarily in the western and central areas of the State (Fig. 3). A decrease in pesticide usage was not reported by any responding agent.

TYPES AND POUNDAGE OF PESTICIDES SOLD BY IN-STATE OUTLETS

In 1968, approximately 3,800 pesticide formulations, involving an estimated 150 base chemicals, were registered for sale in Kentucky (Economic Poison Registration Section, Div. of Regulatory Services, Univ. of Kentucky, Lexington, Ky., *personal communication*). Registrations represented some 480 manufacturers and formulators. Some firms register all their products, although they may not necessarily be sold in the State (there is no additional charge after the first 10 registrations). Registration of pesticides incorporated with commercial fertilizers for agricultural use and special lawn preparations totaled approximately 200.

Data from in-State sales outlets (distribution outlets, manufacturers or their representatives, dealers buying direct, etc.) reflected the sale of 2,850,734 lb of pesticides in Kentucky during 1968 (Table 4). Some 135 base pesticide chemicals were named; in all probability, additional base chemicals were sold but were not reported by these sources because they were overlooked or the poundage was considered unworthy of mention. These sources estimated that the bulk of the poundage was used to treat farmland, although about 5% of this total may have been formulated and packaged in small containers for the home and garden use market. The total poundage of pesticides sold by in-State outlets is listed in Table 4 as herbicides (growth regulators, soil sterilants, defoliants, and fumigants are grouped with herbicides), insecticides, fungicides, and rodenticides, in order of pounds sold.

It was reported that herbicide usage is increasing more rapidly than any of the other groups of pesticides. Three of the 62 herbicides—methyl bromide, maleic hydrazide (MH-30), and atrazine—constituted 67.5% of the pounds of herbicides sold. The first two were used primarily for tobacco, although an undetermined quantity of methyl bromide was used to fumigate hay and

TABLE 4.—*Pesticides sold by in-State outlets, Kentucky—1968 (agricultural usage)*

Compounds	Pounds of Technical Material Sold
HERBICIDES—56.1% OF SALES	
Methyl bromide	431,788
MH-30 (maleic hydrazide)	352,956
Atrazine	200,679
2,4-D (all forms)	142,248
Sodium chlorate	99,047
Diphenamid (Enide®)	49,359
2,4,5-T (all forms)	38,356
Dalapon	30,079
NPA (Alanap®)	22,794
Trifluralin (Treflan®)	22,001
EPTC (Eptam®)	19,373
Amiben	18,224
Calcium hydrogen methanearsonate	16,670
Vernolate (Vernam)	15,845
Sodium arsenite	14,580
Linuron (Lorox®)	14,376
DCPA (Dacthal®)	13,513
Simazine	11,498
CIPC (Chloro-IPC)	10,420
Solan	9,090
DSMA (disodium methanearsonate)	8,294
Paraquat	7,184
Sutan	6,387
Picloram (Tordon®)	4,030
DNOC, sodium salt	3,532
Chloroxuron (Tenoran®)	3,369
Planavin	2,500
Dichlobenil (Casoron®)	2,454
Vorlex®	2,440
Isocil (Hyvar®)	2,400
Metham (Vapam®)	2,118
Benefin (Balan®)	1,614
Dicamba (Banvel-D®)	1,600
Silvex	1,240
Diuron (Karmex®)	1,200
Monuron (Telvar®)	1,200
Amitrole	1,006
CDAA (Randox®)	890
Endothall	600
Misc. herbicides (23)	13,456
Total	1,600,410
INSECTICIDES—31.4% OF SALES	
Chlorinated hydrocarbons (21.8%)	
DDT	151,015
Chlordane	127,778
Aldrin	101,079
TDE (Rhothane®)	94,449
Methoxychlor	46,967
Toxaphene	29,881
Dieldrin	26,979
Endosulfan (Thiodan®)	21,393
Dicofol (Kelthane®)	8,898
Lindane	4,025
BHC	3,456
Heptachlor	2,347
Tetradifon (Tedion®)	1,407
Endrin	500
Subtotal	620,174

TABLE 4.—*Pesticides sold by in-State outlets, Kentucky—1968 (agricultural usage)*—Continued

Compounds	Pounds of Technical Material Sold
INSECTICIDES—31.4% OF SALES—Continued	
Organophosphates (5.3%)	
Malathon	51,467
Diazinon	20,728
Parathion	19,799
Disulfoton (Di-Syston®)	18,858
Naled (Dibrom®)	14,800
Azinphosmethyl (Guthion®)	11,899
Demeton (Systox®)	6,000
Ethion	1,975
Ciodrin®	1,347
Ronnel (Korlan®)	984
Dimethoate (Cygon®)	871
Mevinphos (Phosdrin®)	720
DDVP (Dichlorvos)	536
Misc. organophosphates (5)	394
Subtotal	150,378
Carbamates (2.8%)	
Carbaryl (Sevin®)	80,704
Subtotal	80,704
Miscellaneous (1.5%)	
Lead arsenate	31,467
Pyrethrins	3,076
Piperonyl butoxide	3,025
Rotenone	2,254
Other misc. (9)	1,952
Subtotal	41,774
Total	893,030
FUNGICIDES—12.0% OF SALES	
Sulfur	126,180
Copper sulfate	107,772
Captan	38,590
Zineb	20,620
Maneb	20,527
Ferbam	8,010
Lime sulfur	6,062
Phaltan®	5,905
Cyprex®	3,210
Nabam (Dithane®)	1,168
Polyram® (Metiram)	1,168
Botran®	1,200
Thiram	760
Misc. fungicides (4)	1,523
Total	342,695
RODENTICIDES—0.5% OF SALES	
Warfarin	9,482
Arsenic trioxide	2,916
Zinc phosphide	1,270
Prolan®	699
Misc. rodenticides (4)	232
Total	14,599
GRAND TOTAL	2,850,734

NOTE: For simplicity in reporting, products containing a combination of chemicals, different brand or trade names with the same pesticide(s) were converted to basic chemicals. Salts, acids, etc., of the same basic component are reflected as one compound, such as the salts and acids of 2,4-D. Pesticides of less than 500 pounds are grouped under miscellaneous.

straw for the control of cereal leaf beetle transported into Kentucky from a contaminated out-of-State zone. The remaining 59 herbicides were used to control broadleaf weeds and grasses.

The persistent chlorinated hydrocarbon insecticides were used more extensively in 1968 than any other insecticide group; their sales constituted 69.4% of the total pounds of insecticides sold. Approximately 4¼ lb were sold for every pound of organophosphate compounds.

The chlorinated hydrocarbon compounds were applied as soil insecticides for field crops; foliar sprays on selective food and feed crops and nonfood crops, such as tobacco and seed crops; for selective control of livestock insects; and for household and industrial pest control. As a soil insecticide for field crops, aldrin was the most widely used. An undetermined amount was incorporated into various commercial fertilizer preparations (168 different preparations containing aldrin were registered in 1968). If the amount used in this form were known, aldrin rather than DDT, would probably be the most widely applied persistent pesticide in 1968. Most of the DDT used in Kentucky in 1968 was applied to tobacco.

The 18 organophosphate compounds listed (Table 4) accounted for only 5.3% of the total pounds of pesticides, almost twice the poundage for the carbamates (excusively carbaryl). Malathion was the most widely used followed by diazinon, parathion, and disulfoton. The organophosphates were applied as soil insecticides and as foliar sprays on grain, tobacco, fruit, vegetable, and forage crops. A few of these compounds, including co-ral, malathion, and ciodrin, were used to control livestock insects.

Carbaryl was used primarily as a foliar spray on grain, forage, fruit, and vegetable crops.

The most widely used fungicides were sulfur, captan, zineb, and maneb, constituting 60% of the total in this group. Warfarin was the most prevalent rodenticide.

It is estimated that the total poundage in Table 4 reflects 85% of the actual total pounds of pesticides sold in Kentucky in 1968. The ratio for category of pesticides would probably be the same if the total quantity sold by State outlets were known.

Fourteen of the 135 base compounds sold constituted 73.3% of the total pesticide pounds. These included, in order of volume, methyl bromide, MH-30, atrazine, DDT, 2,4-D, chlordane, sulfur, copper sulfate, aldrin, sodium chlorate, TDE, carbaryl, malathion, and methoxychlor.

From a questionnaire survey of aerial applicators licensed in Kentucky, it was determined that commercial aerial application of pesticides to agricultural crops in 1968 involved less than 10,000 acres, primarily tobacco, small grains, and alfalfa in some 25 counties (Fig. 2). Tobacco accounted for 40% of the total. Approximately 20,500 lb of pesticides (technical material), half of which was MH-30, followed by DDT, toxaphene, and TDE (Rhothane®) were applied by winged aircraft. These four materials constituted 87% of the total. Most of the aerial application to agricultural crops involved application of MH-30 to small plots of less than 10 acres. Pesticides applied by aerial applicators for agricultural purposes were purchased from in-State outlets and are reflected in the data in Table 4.

State agencies, such as the institutional farm system, State universities, the Department of Fish and Wildlife, etc., purchased 38,513 lb of technical materials which included all four groups of pesticides, principally insecticides and herbicides (Division of Purchasing, Kentucky State Department of Finance, Frankfort, Ky., *personal communication*). This poundage was included in 1968 sales data; it was purchased on competitive bids from in-State vendors.

NONAGRICULTURAL USAGE, PURCHASED DIRECTLY FROM OUT-OF-STATE SOURCES

A total of 54 utility companies were surveyed by mail questionnaire concerning the pesticides applied to rights-of-way in Kentucky in 1968. The companies surveyed included railroads; gas transmission, communications, and power companies; and selected rural water districts. All are licensed by the Kentucky Public Service Commission. The rural water districts contacted did not apply any pesticides. The utility companies applied 920,820 lb of materials (exclusively herbicides for weed and brush control) to company-owned property and rights-of-way in numerous areas of the State (Table 5). The principal basic materials used included sodium chlorate-calcium chloride and diuron (Karmex®) mixture; 2,4-D, 2,4,5-T, and various combinations; isocil (Hyvar-X®); and fenuron (Dyhar®). These constituted 95% of the total materials used.

The State Department of Agriculture maintains a mosquito control program in approximately 28 western Kentucky counties and reported spraying 161,500 acres in 1968 (Division of Noxious Weed and Pest Control, Kentucky State Department of Agriculture, Frankfort, Ky., *personal communication*). Officials estimate that about one-half of the acreage was sprayed by winged aircraft either owned by or under contract to the Department. The four materials used in the program included DDT (which is no longer used), Lethane®, malathion, and naled. The 16,800 lb of technical material applied in 1968 were purchased in 1967 directly from the manufacturer and are not part of the sales data.

TABLE 5.—*Pesticides purchased directly from out-of-State sources, 1968 (nonagricultural usage)*

Users	Pounds of Technical Materials Used
Utility Companies	
Railroads (8,647 acres treated)	680,010
Power Companies (7,782 acres treated)	191,070
Gas Transmission Companies (1,511 acres treated)	47,400
Rural Water Districts	—
Commnication (75 acres treated)	2,340
Total (18,015 acres treated)	920,820
Department of Agriculture Mosquito Control Program (161,500 acres treated)	16,800
State Highway Department (39,400 acres treated)	122,955
TOTAL	1,060,575

The State Highway Department applied 122,955 lb of technical material (herbicides only) in 1968 on an estimated 39,400 acres of State rights-of-way (Division of Roadside Development, Kentucky State Department of Highways, Frankfort, Ky., *personal communication*). Application was primarily by truck, and principal materials (about 90% of the total), included 2,4,-D, 2,4,5-T, MH-30, picloram, and dalapon. These materials were purchased from out-of-State firms.

Railroads used 73.8% of the total poundage, followed by power companies (20.7%), gas transmission companies (5.1%), and communications companies (0.4%). The utility firms reported treating approximately 18,000 acres of which 4,000 were treated by out-of-State based helicopters under contract: The remaining 14,000 acres were treated by surface spray rigs particularly designed for trucks and railcars. A small amount of herbicides in pellet and granular form was applied by cyclone distributors. Small quantities of liquid mix were also applied by knapsack and hand sprayers. Approximately 95% of the herbicides applied by contractors or company employees were purchased from out-of-State firms. These were located generally in Pennsylvania, Indiana, and Georgia. Hence, the volume used in utility operations is not reflected in the pounds of pesticides sold by in-State outlets.

Discussion

In Kentucky in 1968, pesticide usage for all purposes totaled more than 3.9 million pounds of technical material purchased from in-State and out-of-State outlets. This represents about 0.5% of the Nation's estimated total of 800 million pounds used domestically (*5*). The poundage for herbicides constituted approximately 67% of the total. Approximately 1,060,575 lb (27% of the total poundage) were purchased from out-of-State sources. Herbicides applied to utility company and State Highway Department rights-of-way constituted all but 16,800 lb (used for mosquito control) of this total.

The total dollar value of pesticides purchased in 1968 for use in Kentucky was estimated at 18 to 20 million dollars. Exact figures cannot be determined because retailers are not required to report sales to any State regulatory agency. The estimate includes small package sales (dusts, liquids, etc.) and specialty pesticides such as aerosols, plunger dispenser devices, pastes, and tablets (all for home or garden use). It is hypothesized that the value would be significantly greater had there been a practical method of estimating dollar sales for special lawn fertilizer preparations containing various pesticides and for pesticides used on Federal Government installations such as military bases or depots, by municipalities, by pest control operators, or by others that may have been excluded in the study who purchase directly from out-of-State sources.

It is likely that millions of dollars are spent on specialty pesticides in various forms for use in and about the home. Most formulations for this market such as aerosols, dusts, and granules are purchased in a form suitable for application without the addition of diluents. Consequently, in terms of pounds of technical material, they constitute only a small segment of the total quantities of pesticides sold and used in 1968, but are much more important in terms of dollar sales.

Although pesticide usage is increasing annually (about 13%-15%), Kentucky ranked very low nationally in 1964 in the percentage of farmland treated, with less than 4% of Kentucky's farmland receiving some type of pesticide treatment (634,341 acres). This may be attributable, in part, to the types of crops grown in Kentucky. In the middle southern and southeastern States few pesticides are applied to soybeans and corn, major crops in Kentucky (Table 1). In addition, tobacco, another major crop in the State, is normally grown on the same soil only once every 2 or 3 years; therefore, the total acreage that receives pesticides in tobacco production is greater than the acreage for a given year (*6*). Hypothetically, if the total poundage had been confined entirely to agricultural use and evenly distributed over all of the State's farmland (16,265,180 acres), it would total less than 0.25 lb (4 oz) of technical material per acre, or use confined to cropland (9,364,980 acres), would amount to less than 0.5 lb/acre. The bulk of pesticides for agricultural purposes are used on grain, tobacco, and hay crops principally grown in 29 central (north, south) and 16 western Kentucky counties (Hardin, Hart, Barren, and those west) (Fig. 1).

From a monetary standpoint (retail), MH-30 was the most important pesticide in 1968, with sales of about 1.5 million dollars. Furthermore, it appeared that more dollars were expended for pesticide use on tobacco than any other crop. Perhaps the two most signficant pesticides to be introduced in recent years in Kentucky are methyl bromide and MH-30. Both are used extensively in the production of tobacco and have been responsible for revolutionizing this particular industry. MH-30, a growth regulator, has all but eliminated the hand control of sucker growth. Methyl bromide, a fumigant, is very effective against soil insects in preparation of tobacco plant beds.

Conclusions

In Kentucky the continued increase in pesticide usage will be an important factor in the growth of the agricultural gross product. It is anticipated that pesticide usage, especially herbicides, will continue to accelerate.

Data on the principal uses, types, and volume of pesticides are important in this era of national concern for the environment, particularly with respect to the persistent pesticides. Such information will provide a basis for projecting future usage trends.

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APPENDIX

*Chemical Names of Compounds Discussed in This Issue**

ALDRIN	Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
ARSENIC	As_2O_3
BHC	1,2,3,4,5,6-hexachlorocyclohexane, mixed isomers
CHLORDANE	1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane
DDE	1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene
DDT (including its isomers and dehydrochlorination products)	1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane; technical DDT consists of a mixture of the *p,p'*-isomer and the *o,p'*-isomer (in a ratio of about 3 or 4 to 1)
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8a-octahydro-1,4-*endo-exo*-5,8-dimethano=naphthalene
ENDOSULFAN (THIODAN®)	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
ENDRIN	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-*endo-endo*-5,8-dimethanonaphthalene
HEPTACHLOR	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindan
ISODRIN	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo, endo*-5,8-dimethanonaphthalene
LINDANE	1,2,3,4,5,6-hexachlorocyclohexane, 99% or more gamma isomer
MIREX	dodecachlorooctahydro-1,3,4-metheno-1*H*-cyclobuta[*cd*]pentalene
PARATHION	*O, O*-diethyl *O*-*p*-nitrophenyl phosphorothioate
POLYCHLORINATED BIPHENYLS (PCB's)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorination
TDE (DDD) (including its isomers and dehydrochlorination products)	1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane; technical TDE contains some *o,p'*-isomer also
TOXAPHENE	chlorinated camphene containing 67% to 69% chlorine
TRIFLURALIN	α,α,α-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine

*Chemical names of compounds discussed in the paper "Pesticide Sales and Usage in Kentucky—1968" are not included in this Appendix.

ERRATA

PESTICIDES MONITORING JOURNAL, Volume 6, Number 1, p. 31. In the paper "Mercury and lead residues in starlings—1970," a number of values included in TABLE 2—*Mercury residues in starlings, 1970* were in error. The corrected table is shown below:

TABLE 2.—*Mercury residues in starlings, 1970*

Sampling Site Number	Mercury Residue [1] (ppm)	Sampling Site Number	Mercury Residue [1] (ppm)	Sampling Site Number	Mercury Residue [1] (ppm)	Sampling Site Number	Mercury Residue [1] (ppm)
1-A-1	0.05	4-C-1	<0.05	2-F-1	<0.05	3-H-1	<0.05
2	0.06	2	<0.05	2	<0.05	2	<0.05
3	1.50	*Mean*		3	<0.05	3	0.05
4	1.90	*SE*		4	0.18	4	0.10
Mean	0.878			*Mean*	<0.083	*Mean*	<0.062
SE	0.417	1-D-1 [3]	0.08	*SE*		*SE*	
		2	0.05				
2-A-1	0.47	3	<0.05	3-F-1	0.13	4-H-1	<0.05
2	<0.05	4	<0.05	2	0.15	2	0.08
3	0.07	*Mean*	<0.058	3	0.13	3	<0.05
4	0.11	*SE*		4	0.09	4	<0.05
Mean	<0.175			*Mean*	0.125	*Mean*	<0.058
SE		2-D-1	<0.05	*SE*	0.010	*SE*	
		2	0.06				
3-A-1	<0.05	3	—	4-F-1	—	2-I-1 [3]	0.08
2	0.07	4	<0.05	2	—	2	0.11
3	<0.05	*Mean*	<0.060	3	0.08	3	<0.05
Mean	<0.057	*SE*		4	<0.05	*Mean*	<0.080
SE				*Mean*	<0.065	*SE*	
		3-D-1	0.05	*SE*			
1-B-1	0.05	2	<0.05			3-I-1	<0.05
2	0.07	3	<0.05	1-G-1	<0.05	2	0.05
3	0.06	4	<0.05	2	0.05	3	<0.05
4	0.14	*Mean*	<0.050	3	<0.05	4	0.08
Mean	0.080	*SE*		4	0.05	*Mean*	<0.058
SE	0.023			*Mean*	<0.050	*SE*	
		4-D-1	0.08	*SE*			
2-B-1	<0.05	2	—			4-I-1	<0.05
2	0.10	3	<0.05	2-G-1	<0.05	2	<0.05
3	0.11	*Mean*	<0.065	2	<0.05	3	<0.05
4	0.06	*SE*		3	<0.05	*Mean*	
Mean	<0.080			4	<0.05	*SE*	
SE		1-E-1	<0.05	*Mean*			
		2	—	*SE*		5-I-1	<0.05
3-B-1	0.08	3	0.05			2	<0.05
2	0.09	4	<0.05	3-G-1	0.05	*Mean*	
3	0.06	*Mean*	<0.050	2	<0.05	*SE*	
4	0.08	*SE*		3	<0.05		
Mean	0.078			4	<0.05	2-J-1	0.10
SE	0.055	2-E-1	0.10	*Mean*	<0.050	2	0.10
		2	0.07	*SE*		3	0.10
4-B-1	0.09	3	0.05			4	0.06
Mean		4	<0.05	4-G-1	<0.05	*Mean*	0.090
SE		*Mean*	<0.068	2	<0.05	*SE*	0.008
		SE		3	<0.05		
1-C-1 [2]	0.06			4	0.10	3-J-1	<0.05
2	—	3-E-1	0.15	*Mean*	<0.062	2	0.22
3	—	2	<0.05	*SE*		3	0.18
4 [5]	<0.05	3	<0.05			*Mean*	<0.150
Mean	<0.055	4	0.08	1-H-1	0.05	*SE*	
SE		*Mean*	<0.083	2	0.06		
		SE		*Mean*	0.055	1-K-1	<0.05
2-C-1 [4]	0.09			*SE*	0.067	2	0.05
2	—	1-F-1	0.11			*Mean*	<0.050
3	<0.05	2	<0.05	2-H-1	0.05	*SE*	
4	0.06	3	0.05	2	0.07		
Mean	<0.067	4	<0.05	3	0.19	2-K-1	0.10
SE		*Mean*	<0.065	4	<0.05	2	<0.05
		SE		*Mean*	<0.090	*Mean*	<0.075
3-C-1	0.08			*SE*		*SE*	
2	—						
3 [3]	<0.05						
4	<0.05						
Mean	<0.060						
SE							

NOTE: — = no sample taken.

[1] Parts per million whole body, wet-weight basis.
[2] 2 birds.
[3] 7 birds.
[4] 8 birds.
[5] 14 birds.

ERRATA—Continued

PESTICIDES MONITORING JOURNAL, Volume 6, Number 1, p. 73-75. In the paper "Decay of parathion and endosulfan residues on field-treated tobacco, South Carolina—1971," the values reported for parathion and endosulfan as pounds of active ingredient applied per acre were in error. Parathion was applied at a rate of .375 lb A.I. per acre rather than the 1.5 lb A.I. per acre as stated, and endosulfan was applied at a rate of .125 lb A.I. per acre rather than .5 lb A.I. per acre. These corrected values should be inserted in the Abstract, in the first paragraph under the Methods and Procedures section, and in Table 1 and Figs. 1 and 2.

PESTICIDES MONITORING JOURNAL, Volume 6, Number 3. In the paper "Residues of organochlorine pesticides, polychlorinated biphenyls, and mercury and autopsy data for bald eagles, 1969, 1970," on page 138, the word *cholera* was misspelled as "chlorea" in the first and second sentences of the third paragraph.

PESTICIDES MONITORING JOURNAL, Volume 6, Number 3, p. 198 and 199. In the paper "Pesticide residue levels in soils, FY 1969—National Soils Monitoring Program," the maps in Figs. 1 and 3 were reversed. The map shown in Fig. 3 belongs with the caption "FIGURE 1.—*Arsenic residues in cropland soil*"; the map shown in Fig. 1 belongs with the caption "FIGURE 3.—*Dieldrin residues in cropland soil.*"

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SUBJECT AND AUTHOR INDEXES

Volume 6, June 1972-March 1973

Primary headings in the subject index consist of pesticide compounds, the media in which residues are monitored, and several concept headings, as follows:

Pesticide Compounds (listed alphabetically by common name or trade name where there is no common name)

Media and Concept Headings

- Degradation
- Experimental Design
- Factors Influencing Residues
- Food and Feed
- Humans
- Pesticide Sales and Usage
- Plants (other than those used for food and feed)
- Sediment
- Soil
- Water
- Wildlife

Compound headings are also used as secondary headings under the primary media and concept headings and vice versa. When a particular paper discusses five or more organochlorines or three or more organophosphates or herbicides, the compounds are grouped by class under the media or concept headings; in the primary headings, however, all compounds are listed individually. The specific compounds or elements which have been grouped in various combinations by class for certain papers are as follows:

Organochlorines

- aldrin
- BHC/lindane
- chlordane
- DCBP
- DDE
- DDT
- dicofol
- dieldrin
- endosulfan
- endrin
- heptachlor/heptachlor epoxide
- isodrin
- methoxychlor
- mirex
- TDE
- toxaphene

Organophosphates

- carbophenothion
- DEF
- diazinon
- ethion
- malathion
- methyl parathion
- parathion

Herbicides

- atrazine
- 2,4-D
- DCPA

In the author index, the names of both senior and junior authors appear alphabetically. Full citation is given, however, only under the senior author, with a reference to the senior author appearing under junior authors.

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